

Mathematics Connection

Published by The Mathematical Association of Ghana (MAG) ISSN 0855-4706



α β φ ϕ δ λ μ π θ σ ω



MATHEMATICS CONNECTION aims at providing a forum to promote the development of Mathematics Education in Ghana. Articles that seek to enhance the teaching and/or learning of mathematics at all levels of the educational system are welcome.

Executive Editor

Prof. B. A. Eshun, Department of Science Education (UCC), Cape Coast

Managing Editor

Dr. K. D. Mereku, Department of Mathematics Education (UEW), Winneba

Editorial Board

Prof. Kofinti, Department of Mathematics, University of Ghana, Legon

Prof. D. N. Offei, Department of Mathematics and Statistics, UCC, Cape Coast

Prof. B. K. Gordor, Department of Mathematics and Statistics, UCC, Cape Coast

Dr. P. O. Cofie, Department of Mathematics Education (UEW), Winneba

Dr. S.K. Aseidu-Addo, Department of Mathematics Education (UEW), Winneba

Mr. J. F. K. Appiah-Cobbold, GES District Directorate, Twifo-Praso

Mrs. B. Osafo-Affum, GES District Directorate, Asuogyaman, Akosombo

Subscription rate for this Volume: ₵45,000.00 (excluding postage)

Orders with payment should be sent to

Managing Editor,

Mathematical Association of Ghana,

C/o Department of Mathematics Education

University of Education, Winneba

P. O. Box 25, Winneba

Tel. (0432) 22139 or 22140 ext. 138

E-mail: dkmerekue@uew.edu.gh

ISSN: 0855-4706

Published by the Mathematical Association of Ghana

© Mathematical Association of Ghana (MAG) 2004

The points of view, selection of facts, and opinions expressed in the **MATHEMATICS CONNECTION** are those of the authors and do not necessarily coincide with the official

Mathematics Connection

Volume 4, 2004



M A G

Published by the Mathematical Association of Ghana

Mathematics Connection Vol. 4 2004

Contents

EDITORIAL	5
Sex-Differences in Attitude of Students Towards Mathematics in Secondary Schools.....	1
ESHUN B. A.....	1
critical Analysis of the Policy Practice of Mathematics Education in Ghana	15
NABIE, M. J. & KOLORAH-EKPALE P. T.	15
Mathematical Model for Water Quality (Portable Water): A Case Study.....	27
DONTWI, I.K., NUAMAH, N.N.N.N., & AWUDI, G.....	27
Basic School Pupils' Strategies in Solving Subtraction Problems	31
OKPOTI, C. A.	31
Helping Students Overcome Mathematics Anxiety.....	39
AWANTA, E. K.	39
Mathematics Teachers' Knowledge of the Subject Content and Methodology	45

EDITORIAL

The Mathematical Association of Ghana (MAG) was 40 years in 2000. Its founding members upheld a vision, which I had been proud of and promoted. As the Chairman from 1976 to 1979, I supported the promotion of this vision, – i.e. “to improve the teaching and learning of mathematics,” – which is still relevant today but with a different meaning than in the 1960s and 70s. I am glad to note that past and current officers and members of the Association have pursued the vision. In the 2000s, the Association should aim at bringing current thinking and innovations in mathematics education to teachers, students and classrooms, in and across Ghana.

The Association was formed to serve not only its members but also the students and teachers in our schools as well as some significant institutions. In my view, the Association has lived to expectation and provided distinguished service in promoting the teaching and learning of mathematics in Ghana.

Firstly, the Association through its leadership and individual members have provided the Ministry of Education and the Ghana Education Service the expertise needed especially in the areas of curriculum development and in-service training of teachers. Secondly, the West African Examinations Council (WAEC) has called on the leadership and members of the Association on several occasions for their contribution towards the development, and revision, of various mathematics syllabuses as well as in the conduct of examinations. Thirdly, secondary school teachers and students had benefited a lot from the excellent Joint Schools Project (JSP) Mathematics textbooks, which introduced the New Math or Modern Mathematics in Ghana in the 1960s.

Without the foresight of the founding members and the sacrifices of some dedicated members who toiled during school time and vacations to write the JSP textbooks, Ghana would have been left behind in the developments in mathematics education in the 1960s and 1970s. In fact the success of the JSP was such that it became a household name, not only in Ghana but also throughout Nigeria, Sierra Leone and the Gambia. The JSP was adapted for use in the Caribbean as well as adopted by a school in Britain.

The Association in turn owes a debt of gratitude to the Ministry of Education and the Ghana Education Service for providing financial and other material support for its Conferences and Workshops. The Association salutes the various Ministers of Education, Director-Generals, Regional Secretaries of the PNDC era, Regional Ministers, District Chief Executives, Regional, Municipal and District Directors of Education for their participation in its Conferences and Workshops. The Association also owes a great debt of gratitude to the British Council for its financial and material support since the Associations formation in the 1960s. By the support of the British Council, (now DFID), the Association organised a number of in-service training programmes for hundreds of secondary school and teacher training college teachers in the use of the JSP mathematics textbooks.

The Association is a voluntary organisation with no paid officers. Thus its successes and achievements are largely due to the commitment of its officers

and members. Many individuals have toiled without any financial rewards or significant recognition to enable the Association function effectively and hold its national and regional workshops as well as carry out textbook development. The list of such people is very long but I believe it is in order to single out the following few persons for special mention:

- Dr. E. Mary Hartley was as Senior Lecturer, Department of Mathematics, University of Ghana in the 1960s and 1970s. She was a founding member and the first President of MAG. Her enthusiasm to see the teaching of mathematics flourish in Ghana drove her to initiate contacts for the funding and the development of the Joint Schools Project (JSP) Mathematics textbooks and the Project in Advanced Mathematics textbooks. She contributed as an author of these 10 books as well as assist to train secondary school teachers in Modern Mathematics during vacation courses. She also served for several years on the MAG Council with commitment and dedication.
- Mr. C. John Fletcher was a mathematics teacher at Mfantshipim and Achimota Schools in the 1960s and early 1970s. He contributed greatly to the development of both the JSP and Project in Advanced Mathematics textbooks as well as the organisation of in-service vacation courses for MAG members. He served the Association with commitment and dedication.
- Prof. F.K.A. Allotey, the chairman, Ghana Atomic Energy Commission, was the former Head, Department of Mathematics and Dean, Faculty of Science, UST, Kumasi. He was the President of MAG in the 1980s and served three two-year terms. He succeeded not only to organise an international workshop in the teaching of mathematics in Côte d'Ivoire in 1987 but also made it possible for three members of MAG to attend the two-week workshop. His strong desire to help promote the training of mathematicians and the teaching of mathematics has made him establish the National Centre for Mathematical Sciences at the Ghana Atomic Energy Commission, Kwabenya-Accra. Many young mathematics lecturers and secondary school teachers have benefited from workshops and formal training at the Centre since 1998. He provided exemplary leadership and served the Association with commitment.
- Mr. J. Harry Johnson was a mathematics teacher at Mfantshipim School from the late 1950s to the 1970s but is still teaching mathematics long after his retirement. He was the only Ghanaian to contribute to the writing and development of the JSP mathematics textbooks. He served the MAG as its National Secretary from 1973 to 1976. His greatest contribution was the enthusiasm, dedication and the leadership he provided to enable MAG organise several in-service training vacation courses for teachers at both the primary and secondary school levels from 1972 to 1978. He served the Association with commitment and dedication.

The “Edinkanfo” have done a lot to make the Association what it is today. I believe the MAG has a lot to do to offer good mathematics educational ideas to its members, the pupils/students in our schools and the education system as a whole. Many new approaches and innovations as well as the use of calculators and computers in the teaching of mathematics are available and appropriate for our environment. I entreat those who have

such knowledge to share with their colleagues or use them in the mathematics classrooms. Those who want to lead the Association in the 2000s must definitely be prepared to champion this cause. No one should be teaching mathematics at any level from primary to the university with only a textbook and a piece of chalk in hand in the 2000s. Pupils/students must use manipulatives, worksheets of relevant activities, calculators and where possible computers to learn and do mathematics in the 2000s.

The emphasis on the girl-child in mathematics education should also be the focus of the Association in the 2000s. Statistics show that many mixed schools now have far more girls in SSS than boys. Mathematics teachers should by good teaching attract more girls to do Elective Mathematics than boys and as a result encourage more girls to do mathematics at the university level. This is not merely a challenge to members but an ultimatum otherwise Ghana's technological development will lag behind as we neglect girls – the “half of our future” in the pursuit of mathematical knowledge.

In its forty years of existence, the Association has published the following periodicals/journals:

- Nyansapow;
- Mathematics Connection;
- MAG Journal.

The last issue of the MAG Journal was published nearly two decades ago. I am very much pleased with the efforts of the MAG Council in ensuring that this special fortieth anniversary edition (which is Volume 12) of the journal is published.

In all there are eight articles in this volume which examine various issues in mathematics education including

- attitude of secondary school students to mathematics
- methods in primary mathematics textbooks and teachers' classroom practice
- constructivism and mathematics education in Ghana
- study of language policy practice in the teaching of mathematics
- mathematical model for water quality
- overcoming mathematics anxiety
- pupils' strategies in solving subtraction problems
- mathematics teaching/learning in basic and senior secondary schools
- mathematics teachers' knowledge of the subject content and methodology.

I hope we will join hands and work harder to improve mathematics education in Ghana at all levels. To the MAG Council, and the entire members, I say Well done – Ayekoo!!!

Dr. B. A. Eshun

[President, MAG]

Sex-Differences in Attitude of Students Towards Mathematics in Secondary Schools

ESHUN¹ B. A.

Abstract

The purpose of the study was to investigate Ghanaian secondary school students' attitudes towards mathematics. In particular, the study investigated the students' attitudes along the following seven dimensions: Confidence in learning mathematics; Usefulness of mathematics; Success in mathematics; Effective motivation; Mathematics anxiety; Mathematics as a male domain; Understanding mathematics; and Like doing mathematics. The study involved 1419 students from 12 secondary schools in the Central and Western Regions of Ghana. Data was collected using a questionnaire consisting of 65 items, some of which consisted of statements to which the students were required to agree or disagree to reflect their feelings and attitudes towards mathematics. The results of the study indicate differences in attitude between sexes in single-sex and mixed schools. Girls in mixed schools expressed the least success and confidence in doing mathematics as well as had higher mathematics anxiety. Less than half the students had mathematics anxiety. Slightly more than half the students were not effectively motivated to do mathematics. Over eighty percent of male students in single-sex schools like mathematics but only about half of the females in mixed schools did. While girls in single-sex schools expressed more confidence, girls in mixed schools expressed far less confidence than boys in both single-sex and mixed schools. In general the students had positive attitudes towards mathematics especially along the attitudinal variables, usefulness of mathematics, like mathematics and success in doing mathematics.

Introduction

Despite the meaningful learning of Brownell (1928) and insightful psychological and learning theories of Piaget (1958), Bruner (1966), Dienes & Golding (1971), Gagné (1968) and Skemp (1979), the learning of mathematics is still far from satisfactory. Thus Begle and Gibb (1980) observed that while psychology has provided us with general theories of learning, we have no established general theory to learning mathematics to provide a basis for mathematics education. Researchers have revealed the under-achievement in mathematics by significantly large numbers of children in many countries (Cockcroft, 1982; Husen, 1967; Carpenter, Coburn, Reys and Wilson, 1978) including Ghana (Eshun, 1999). The task

¹ Benjamin A. Eshun (Ph.D.) is a Professor in Mathematics Education at the University of Cape Coast, Ghana. He was the president of the Mathematical Association of Ghana from 1998 to 2000. The study was conducted by Prof. Eshun and analysed with the assistance of Malemuo, A, Okpodjah, B. T. and Wilson-Tagoe, G. A. in 1991.

for research in mathematics education is to provide information that would help "to understand better, how, where and why people learn or do not learn mathematics" (Begle and Gibb, 1980:8). The determinants that affect the learning of mathematics include the learner's intellectual ability, maturity, learning style, emotional and social adjustment as well as attitudes.

People develop attitudes towards mathematics just as they tend to develop attitudes towards people and a lot of things such as politics, religion, institutions and school subjects. Allport's (1935) definition of attitude implies that attitude is a state of an individual's mind that has resulted through experience and directs how that individual should respond to an object or situation that is related to or associated with it. On the other hand, Rokeach's (1972) definition implies that attitude is the result of several beliefs a person holds that makes him or her respond in a preferential way towards an object or situation. Staats' (1981) definition agrees in principle with Allport's (1935) that attitude is not innate, it is a learned disposition and therefore could be changed, and it permits response to things in some way. The objects or situations in all the above definitions may be mathematics itself, solving mathematics problems, understanding concepts in mathematics, usefulness of mathematics or motivation for learning mathematics. Thus we shall define attitude towards mathematics as a disposition towards an aspect of mathematics that has been acquired by an individual through his or her beliefs and experiences but which could be changed.

A study to determine the relationship between attitudes and achievement is very useful if aspects of attitudes positively influencing achievement could be isolated. However, research indicates that there is a low positive correlation between attitudes and achievement (Crosswhite, 1972). Nevertheless, common sense reveals that one is likely to achieve higher in something one enjoys doing, has confidence in learning or finds useful. Thus positive attitudes towards various aspects of mathematics is desirable. Attitudes towards mathematics may influence the readiness and willingness with which an individual would learn and benefit from mathematics instruction.

Difficulty in Learning Mathematics

It is a general belief that among all school subjects, mathematics is the most difficult and the most feared subject, especially by females. Peter Richards (1982:59) says that if asked to sum up their view of mathematics at school many people would describe it in terms of one, if not all, of the three D's - **dull, difficult** and **dislike**. Richards (1982) cited Burton (1979) in a research in which most of the people selected could remember reactions like, "oh, my God, I'm going to make a fool of myself", and described how they associated mathematics with fear and trembling, or a complete detachment. She also reported physical symptoms of panic and despair, like cold sweats, clammy palms and a lump in the throat feelings. Such are the negative emotions or feelings that are usually associated with doing mathematics and contribute in a large extent to the poor performance in mathematics examinations. Significant individuals have also expressed various attitudes towards mathematics that affect the ability to learn to succeed in the subject.

Clements (1979) also described how as far back as 1880s, the Australian novelist Ethel F. L. Robertson, using the pseudonym, Henry H. Richardson

wrote about her dislike for mathematics as well as her poor performance in the subject as follows:

My particular bogey was mathematics, a subject to which I seem to have been born deaf and blind, and quite incurable. Yet, as things stood, I had to grind at it with the rest.

Also, in 1972, Prince Philip, the Duke of Edinburgh expressed his attitude towards mathematics and mathematicians as follows:

Those fortunate beings who find mathematics a joy and fascination will probably get on, whatever the standard of teaching. It requires real genius to light a flicker of understanding in the minds of those to whom mathematics is a clouded mystery (Howson, 1973)

Hudson (1966) and Aiken (1976) cite personality as an important factor in learning mathematics. The personality factors include how the learner perceives the subject, for instance, is it useful and important, and the relationship between the learner and his/her environment (teacher, parents, peers, classrooms, etc). The reaction of individuals to both the subject and the teachers of mathematics caused Lazarus (1974) to coin the term '*mathophobia*' which he defines as 'an irrational and impeditive dread of mathematics'.

Confidence and Anxiety

The confidence and anxiety variables are important affective variables as well as helpful in the explanation of the sex-related differences in the learning of mathematics. Tobias and Weissbrod (1980) cited anxiety as a strong factor for girls to avoid mathematics and mathematics related courses, because they tend to suffer more from 'mathematics anxiety' than do boys. This anxiety has been described as a kind of panic or helplessness that develop when a mathematics problem is presented. It is human nature that one tends to do the things that one feels one is confident in doing, and that one avoids those things, which one thinks, may arouse anxiety.

Callahan and Clennon (1975) provided an evidence to show that high anxiety is associated with lower achievement in mathematics and also that there is a positive relationship between self-esteem and mathematics achievement. Leviton (1975), Prinanera et al (1974) and Buckman (1970) also agreed that anxiety might influence females' willingness to study mathematics.

Fennema (1979) and Fink (1969) used instruments to measure specific mathematics anxiety in order to explore the relationship of mathematics and mathematics learning and found that there was strong correlation between anxiety and mathematics learning. Fennema and Sherman (1977) also found that anxiety and confidence appeared similar because high rating on the confidence scale correlated highly ($r=0.89$) with a low rating on the anxiety scale. They found also that from grade 6 to 12, boys were significantly more confident in their abilities to deal with mathematics than were girls even when there were no significant sex-related differences in mathematics achievement. In addition, they obtained evidence to show that confidence in mathematics learning and achievement was more highly correlated than any affective variables and achievement.

Crandall, et al (1962) and Maccoby and Jacklin (1974) concluded that girls underestimate their own ability to solving mathematics problems than boys do because of lack of confidence in themselves and also due to mathematics

anxiety. In other studies, Fennema (1979) and Wolleat et al (1979) observed that females develop a lack of confidence in their own ability to do mathematics and attribute their success to factors like luck, other than their own ability.

Usefulness of Mathematics and as a Male Domain

Fox (1977) and Casserly (1975) identified the perceived usefulness of mathematics as another affective variable, which helps to explain females not electing to take mathematics. According to Fennema (1979) as a group, females in secondary schools indicate they do not feel they will need or use mathematics in the future. But males as a group are much more apt to report that mathematics is essential for whatever career they plan. The sex-differences in perceived usefulness are also related to the stereotyping of mathematics as male domain. Fennema (1979) concluded that if females do not see mathematics-related careers as possibilities, they might also not see mathematics as useful. Fennema (1979) also observed that mathematics has traditionally been regarded as a male domain. Male superiority in mathematics learning has been accepted as a fact, almost without question for many years. Perhaps today, many more males use mathematics daily than females. For example, careers which use mathematics as tools: engineering, surveying and others confirm that males dominate mathematics related occupation. Maccoby and Jacklin (1974) concluded that one of the few intellectual sex-differences that still exists is male superiority in mathematics ability.

Stein and Smithells (1969), and Stein (1971) have evidence showing that females and males do not consider mathematics masculine until adolescent years. Stein and Smithells (1969) found evidence that twelfth grade female subjects perceived that the use and creation of mathematics is a male domain. Fox (1977) revealed that parents, teachers and counsellors also believe mathematics is more of males' activity than it is for females.

Purpose of Study

While research on students' attitudes have received considerable attention by mathematics educators since 1970s (Aiken, 1976), little evidence is available in Ghana on studies conducted to ascertain the attitudes of Ghanaian students towards mathematics. There is the need therefore to measure the attitudes of students towards mathematics in Ghana since mathematics is compulsory for all secondary school students, and therefore students who dislike the subject "have to grind at it with the rest" (Clements, 1979) .

Studies by Eshun (1990, 1999) showed that the achievement of students in Ghana in mathematics is low and there are significant differences in the achievement of male and females in favour of the former. It is important to measure the attitudes of students towards mathematics in order to identify areas of students' attitudes that might contribute to the low achievement, and suggest corrective measures to improve the learning of mathematics in Ghana.

Research has identified various dimensions along which attitude variables could be measured. Fennema and Sherman (1977) used an attitude scale which measured attitudes along the following seven dimensions:

- like doing mathematics,

- confidence in learning mathematics,
- usefulness of mathematics,
- effective motivation,
- mathematics anxiety,
- mathematics as a male domain, and
- understanding mathematics

The purpose of this study was to investigate the attitudes that Ghanaian secondary school students have towards mathematics. In particular, the study investigated the students' attitudes along the seven dimensions of Fennema and Sherman (1977), plus how students rate their success in the subject. The study also investigated the relationship between the various aspects of students' attitudes. For example, how seeing mathematics as useful relate to the students' confidence in learning the subject or their anxiety towards it.

Method

The Subjects

The study involved 1419 students from 12 secondary schools in the Central and Western Regions of Ghana. The schools had students from all the 10 regions of the country. Ten schools had about 99 percent boarding students, only one was a day school and another had less than 30 percent day students. The students were in the fifth year of their secondary education in 1990. The breakdown of the students by type of school and sex is presented

Table 1. Students by type of school and sex

Single-sex School		Mixed School		All
Male	Female	Male	Female	
505	381	271	262	1419

in Table 1.

Instrument

The instrument used for the collection of data was a questionnaire consisting of 65 items and divided into three parts. Part 1 requested for background information on the students. Part II requested for information on the student's participation in different mathematics programmes and estimates of his/her performance in mathematics. Part III consisted of items or statements to which the student was required to agree or disagree to reflect his/her feelings and attitudes towards mathematics. An example, shown in Figure 1, was provided to show the student how to respond to the statements. The Likert scale of attitude scores was used. The scores of 1, 2, 3, 4, and 5 were given to the responses Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D) and Strongly Disagree (SD) respectively, as shown in Table 2.

The items or statements in Part III were grouped to form eight attitudinal variables each regarded as a dimension along which a score reflects a positive or negative attitude of a student. The eight dimensions and attitudinal variables were as follows:

1. Confidence in learning mathematics
2. Usefulness of mathematics
3. Success in mathematics
4. Effective motivation
5. Mathematics anxiety
6. Mathematics as a male domain
7. Understanding mathematics
8. Like doing mathematics.

Table 2. Weights Attached to Responses

Statement	1	2	3	4	5
	SA	A	U	D	SD
1. At least half of the students in every secondary school should be day.		×			
2. Sports and games should not form part of the secondary school curriculum					×

Table 3 shows the eight attitudinal variables and typical items or statements in the questionnaire that reflect the attitude being measured.

Table 3 Attitudinal Variables and Typical Items

Item	Variable	Statement	SA	A	U	D	SD
44	Confidence	No matter how hard I try, I find mathematics very difficult.					
40	Usefulness	I like mathematics because it has many applications.					
24	Success	I don't think mathematics is fun, but I always want to do well in it.					
22	Motivation	I would like to take mathematics even if it was not compulsory for Ordinary Level G.C.E.					
50	Anxiety	I have always been afraid of mathematics.					
54	Male Domain	I think parents encourage their sons to do mathematics and not their daughters.					
45	Understanding	No teacher has been able to make me understand mathematics well enough.					
58	Like Maths	Mathematics thrills me, and I like it better than any other subject.					

Procedure

The questionnaire was administered to all the students in Form 5 of the selected in classrooms and supervised by teachers. The investigator collected

the completed questionnaires from the schools and analyzed them using the computer. The responses were analyzed according to type of school (single-sex male, single-sex female and mixed) and sex. Tests for relationships were conducted at 0.001 or 0.01 level of significance.

Table 4 shows the items or statements (positive and negative) on the questionnaire contributing to each attitudinal variable. The coding of students' responses were done in such a way that the codes reflected the response to a positive statement. For example, if a student disagreed with a negative statement then the response will be interpreted as "agree", and if strongly disagreed it will be interpreted as "strongly agree".

Table 4 Questionnaire items contributing to the various dimensions by nature of statement

Attitude Variable	Statement	
	Positive	Negative
Confidence in Mathematics	19, 30	29, 44, 56
Usefulness of Mathematics	31, 35, 37, 40, 42, 43	
Teacher Effect	47, 52, 61, 64	38
Success of Mathematics	20, 24	23, 44
Effective Motivation	22, 41, 30	32
Mathematics Anxiety	21, 28, 34, 50, 63	60
Mathematics as Male Domain	49, 51, 54, 55, 61, 62, 65	46, 53
Understanding Mathematics	-	25, 36, 39, 45
Like Mathematics (problems)	26, 27, 33, 57, 58, 59	28, 29, 48

Results

The attitude scale of 1 to 5 used to measure the attitudinal variables indicates that a score of less than 3 measures a positive characteristic of that attitude variable and on the other hand, a score of greater than 3 indicates a negative characteristic of the attitude variable. In addition, the nearer the score is to 2 the more positive the characteristic of the attitude and the nearer the score to 4, the more negative the characteristic of the attitude is along the dimension measured.

Table 5 shows the percentage of students selecting positive (strongly agree or agree) responses on the attitude scale according to type of school and sex. The table shows that over half the students in the study reacted positively to all the eight attitude variables measured. The three highest positive responses were for the variables, like mathematics, confidence in learning mathematics and usefulness of mathematics, in that order. The least positive response was for mathematics anxiety followed by effective motivation. While over 60 percent of the students in single-sex schools considered mathematics as a male domain subject, less than half the students in mixed schools did think so.

Table 5 Percentage Of Students Selecting Positive Response For Various Attitudinal Dimensions By Type of School and Sex.

Attitude Variable	Single-Sex		Mixed		All
	Male	Female	Male	Female	
Usefulness of Mathematics	73.6	71.7	65.8	62.5	69.6
Like Mathematics	84.9	73.8	65.0	55.9	72.8
Mathematics as Male Domain	61.2	62.2	45.4	41.6	54.8
Success in Mathematics	68.1	61.9	64.1	60.0	64.2
Confidence in Mathematics	77.9	84.0	64.4	51.7	72.0
Effective Motivation	57.8	44.6	63.6	52.0	54.3
Understanding Mathematics	74.5	79.8	59.7	52.0	68.9
Mathematics Anxiety	33.3	44.0	45.0	55.4	42.5

Table 6 Means of Attitude Scores by Type of School

Attitude Variable	Single-Sex		Mixed	All
	Male	Female		
Usefulness of Mathematics	2.23	2.50	2.36	2.35
Like Mathematics (problems)	2.36	2.52	2.46	2.44
Mathematics as Male Domain	2.93	2.74	3.01	2.91
Success in Mathematics	2.31	2.54	2.50	2.44
Confidence in Mathematics	2.54	2.46	2.60	2.54
Effective Motivation	2.75	2.94	2.62	2.75
Understanding Mathematics	2.39	2.32	2.68	2.48
Mathematics Anxiety	2.66	2.90	3.17	2.92
Number	505	381	553	1419

More than two-thirds of the males in single-sex schools reacted positively to six attitude variables in nearly the same order as for the entire student population. Also, more than half the females in single-sex schools reacted positively to seven of the attitude variables. In the mixed schools, more than half the males and females responded positively to six and seven attitudinal variables respectively. Less than half the females in single-sex schools were positively motivated to learn mathematics. Only about two-fifths of students in single-sex schools possessed mathematics anxiety but about half the students in mixed schools did. Females in both single-sex and mixed schools expressed mathematics anxiety more than their male counterparts.

Table 7

Correlation Coefficients between Attitudinal Variables and Their Individual Component Items for Single-Sex Female Schools

Confidence in Maths	Usefulness of Maths	Effective Motivation	Maths Anxiety	Maths as Male Domain	Under- standing Maths	Like Maths	Success in Maths
19; 0.48*	31; 0.66*	22; 0.65*	21; 0.54*	46; 0.10	25; 0.51*	26; 0.40*	20 0.46*
29; 0.38*	35; 0.63*	30; - 0.06	28; 0.57*	47; 0.38*	36; 0.53*	27; 0.57*	23; 0.65*
30, 0.30*	37; 0.64*	32; 0.73*	34; 0.60*	49; 0.54*	39; 0.10	28; 0.44*	24; 0.22**
44; 0.47*	40; 0.66*	41; 0.64*	50; 0.66*	51; 0.65*	45; 0.68*	29; 0.17	44; 0.64*
45; 0.26*	42; 0.66*		60; 0.56*	52; 0.25*		33; 0.33*	
	43; 0.66*		63; 0.03	54; 0.55*		48; 0.46*	
				55; 0.50*		57; 0.50*	
				62; 0.54*		58; 0.56*	
				65; 0.58*		59; 0.54*	

*Significant at 0.001

**Significant at 0.01

Table 6 shows the means of scores on the eight attitude dimensions by type of school and sex. The table shows that the mean scores for all students in the population were less than 3 for all attitude variables. This is consistent with the results in Table 3 and shows that the students selected more positive items of the attitude dimensions. The most positive responses were for usefulness of mathematics, like mathematics and success in mathematics in that order. The table confirms that students in single-sex schools have positive attitudes in all the eight dimensions and males regarded mathematics as a male domain more than the females but the latter had more mathematics anxiety. Students in mixed schools were undecided about mathematics as a male domain.

Table 7 shows the relationship between each item or statement and its attitude dimension variable according to the responses of only females in single-sex schools. The table shows that all the items of the variables, confidence in learning mathematics and usefulness of mathematics were significantly correlated to their respective attitude variables at 0.001 level of significance. Also, only one item, "I think mathematics is the most enjoyable subject I have taken" of the variable, effective motivation was negatively but not significantly correlated to its attitude variable. The item was rather positively and significantly correlated to the variable, confidence in learning mathematics at 0.001 level of significance.

The item that did not correlate significantly with mathematics anxiety was "I am embarrassed to ask questions in mathematics class." The item that did not correlate significantly with the variable, 'mathematics as a male domain', was, "I would like to see many females students at the university doing mathematics."

The item that did not correlate significantly with understanding mathematics was, “In class I seem to understand but when I am given homework to do I can’t”. The item, “I find it difficult to solve mathematics problems on my own”, correlated significantly at 0.001 level of significance with the variable, “confidence in mathematics”, but not with the variable, “like doing mathematics”.

Table 8 also shows the correlation coefficients between the scores of the various attitudinal variables for only females in single-sex schools. The table shows that all but one correlation coefficient between the variable, “mathematics as a male domain” and the other variables were negative. The

Table 8 *Correlation Coefficients Between Attitudinal Variables for Single-Sex Female Schools*

Attitude Variable	Confidence	Useful-ness	Success	Effective Motivation	Maths Anxiety	Male Domain	Under-standing	Like Maths
Confidence	-	0.16	0.35	0.28	0.14	-0.07	0.23	0.23
Usefulness		-	0.45	0.27	0.31	-0.05	0.22	0.53
Success			-	0.38	0.42	-.07	0.36	0.43
Effective Motivation				-	0.14	-0.12	0.29	0.29
Maths Anxiety					-	-0.10	0.26	0.50
Male Domain						-	-0.08	0.05
Under-standing							-	0.28
Like Maths								-

most positive and significant correlation coefficients were between “like doing mathematics” and the variables, “usefulness of mathematics”, “mathematics anxiety” and “success in mathematics” on the other hand. Also, there was a large positive and significant correlation between the variable, success in mathematics and the variables, confidence in learning mathematics, usefulness of mathematics, understanding mathematics, mathematics anxiety and effective motivation. This implies that on the whole the responses of the females in single-sex schools were consistent among all the attitude variables except the variable mathematics as a male domain.

Discussion

Apart from one item, “I think mathematics is the most enjoyable subject I have taken” which was negatively correlated to the variable, Effective Motivation, all the other items correlated positively with the attitude variables they measured. Nearly all the correlation coefficients were significant at 0.001 level.

Girls in mixed schools expressed the least success and confidence in doing mathematics as well as had higher mathematics anxiety. This supports the finding by Maccoby and Jacklin (1974) that girls underestimate their own ability to solve mathematics problems due to lack of confidence and mathematics anxiety.

Less than half the students had mathematics anxiety. Slightly more than half the students were not effectively motivated to do mathematics. Over eighty percent of male students in single-sex schools like mathematics but only about half of the females in mixed schools did.

While girls in single-sex schools expressed more confidence, girls in mixed schools expressed far less confidence than boys in both single-sex and mixed schools. The finding for girls in mixed school supports that of Fennema and Sherman (1977) but not the finding for the girls in single-sex schools.

As a group students in single-sex schools saw mathematics as a male domain but those in the mixed schools were neutral. Males and females in single-sex schools saw mathematics as a male activity than their counterparts in mixed schools respectively. Though the majority of the students think mathematics is a male domain, they would also like to see more females take mathematics at a higher level than the secondary school. This accounts for the non-significant correlation of the item, "I would like to see many females students at the university doing mathematics," with the variable, mathematics as a male domain.

The study shows that in general the students had positive attitudes towards mathematics especially along the attitudinal variables, usefulness of mathematics, like mathematics and success in doing mathematics. However, the students were least positive about effective motivation and confidence in doing mathematics. The students in the study were the same ones used in the study by Eshun (1990, 1999), thus their low achievement in mathematics could partly be attributed to lack of motivation and confidence to learn the subject. This finding is consistent with that of Callahan and Clennon (1975) that there is a positive relationship between self-esteem and mathematics achievement.

The result shows that students who liked mathematics saw mathematics as useful, had success in doing mathematics and had less anxiety in mathematics. Students who had success in doing mathematics also had confidence in learning mathematics, saw mathematics as usefulness, had understanding of mathematics, had less mathematics anxiety and were effectively motivated. However, students' attitudes towards mathematics as a male domain were negatively correlated to six variables excluding like doing mathematics. This is consistent with the findings of Fennema (1979), Maccoby and Jacklin (1974), Stein and Smithells (1969) that adolescent boys and girls see mathematics as a male activity.

Mathematics teachers must use the positive attitude of students towards mathematics as an indication that they can be effectively assisted to learn mathematics. In addition, teachers must provide the environment that motivates students, especially girls in mixed schools, and lessen their anxiety and rather build their confidence in doing mathematics.

References

- Aiken, L. R. (1976). Update on attitudes and other affective variables in learning mathematics. *Review of Educational Research*, 46, 293 – 311.
- Allport, G. W. (1935). Attitudes. In C. Murchison (Ed.), *A handbook of social psychology*. Worcester, Mass.: Clark University Press.

- Begle, E. G. & Gibb, E. G. (1980). Why do research? In R. J. Shumway (Ed.), *Research in mathematics education*. National Council of Teachers of Mathematics.
- Brownell, W. A. (1928). *The Development of children's number ideas in the primary grades*. Chicago: The University of Chicago.
- Bruner, J. S. (1966). *Toward a theory of instruction*. Cambridge, Massachusetts: Belknap Press.
- Buckman, A. M. (1970). The relationship between seventh-grade pupil's academic self-concept and achievement in mathematics,. *Journal for Research in Mathematics Education*, 1.
- Burton, G. (1979). Regardless of sex. *Mathematics Teacher*, 72, (4), 261 – 270.
- Callahan, L. G. & Glennon, V. J. (1975). *Elementary school mathematics: A guide to current research*. Association for Supervision and Curriculum Development, Washington, D.C.
- Carpenter, T., Coburn, T. G., Reys, R. E. & Wilson, J. W. (1978). *Results from the first mathematics assessment of the national assessment of educational progress*. National Council of Teachers of Mathematics.
- Casserley, P. L. (1975). *An assessment of factors affecting female participation in advanced placement programs in mathematics, chemistry and physics*. (Grant No. GV – 11325), National Science Foundation, Washington, D.C.
- Clements, M. A. (1979). Sex differences in mathematical performance: An Historical Perspective. *Educational Studies In Mathematics*, 10.
- Cockcroft, W. H. (1982). *Mathematics counts*. HMSO, London.
- Crandall, V. J., Katovsky, W & Preston, A. (1962). Motivational and ability determinants of young children's intellectual achievement behaviours. *Child development*, 33.
- Crosswhite, F. J. (1972). *Correlates of attitudes toward mathematics*. NLSMA Report No. 20; Pasadena, Calif.: A. C. Vroman.
- Dienes, Z. P. & Golding, E. W. (1971). *Approach to modern mathematics*. New York: Herder and Herder.
- Eshun, B. A. (1990). *Sex-related differences in mathematics achievement of secondary school students*. An unpublished paper, University of Cape Coast.
- Eshun, B. A. (1999). The pattern of mathematical achievement of secondary school students in Ghana. *Journal of Science and Mathematics Education*, Vol. 2, 1, 22 – 33.
- Fennema, E. & Sherman, J. (1977). Sex-related differences in mathematics achievement, spatial visualization and affective factors. *American Educational Research Journal*, 14, 51-71.
- Fennema, E. (1979). Women and girls in mathematics – Equity in mathematics education. *Educational Studies In Mathematics*, 10.
- Fink, N. B. (1969). Self-concept as it relates to academic underachievement. *California Journal of Educational Research*, 13.

- Fox, L.H. (1977). The effects of sex role socialization and mathematics participation and achievement. women and mathematics: Research perspective for change – *NIE Papers in Education and Work*, No. 8.
- Gagné, R. M. (1968). Learning hierarchies. *Educational Psychologist*, 6 (1), 1 - 9.
- Howson, A. G. (Ed.). (1973). *Development in mathematics education-proceedings of the second international congress on mathematical education*, Oxford University Press.
- Hudson, T. (1967). *International study of achievement in mathematics: A comparison of twelve countries*. John Wiley Almquist and Wiksell, New York Stockholm, 2 vols.
- Husen, T. (Ed.). (1967). *International study of achievement in mathematics: A comparison of twelve countries*, Vol. II. New York: Wiley.
- Leviton, H. (1975). The implications of the relationship between self-concept and academic achievement. *Child Study Journal*, 5.
- Maccoby, E. E. & Jacklin, C. N. (1974). *The psychology of sex differences*. Stanford University Press, Stanford, California.
- Piaget, J. (1958). *The growth of logical thinking from childhood to adolescence*. New York: Basic Books.
- Primavera, L. H., Simon, W. E. & Primavera A. (1974). The relationship between self-esteem and academic achievement: An investigation of sex differences. *Psychology in the Schools*, 11.
- Richards, P. (1982). Difficulties in learning mathematics. In Cornelius, M. (Ed.). *Teaching mathematics*. CROOM HELM, London and Canverra.
- Rokeach, M. (1972). *Beliefs, attitudes and values*. San Francisco: Jossey-Bass.
- Skemp, R. R. (1979). *Intelligence, learning and action*. New York: Wiley.
- Staats, (1981). An outline of an integrated learning theory of attitude. In Fisbein (ed.) *Reading in attitude theory and measurement*. New York, Wiley.
- Stein, A. H. & Smithells, J. (1969). Age and sex differences in children's sex role standards about achievement. *Development Psychology* 1.
- Stein, A. H. (1971). The effects of sex role standards for achievement motivation. *Development Psychology*, 4.
- Tobias, S. & Weissbrod, C. (1980). Anxiety and mathematics: An update, *Harvard Educational Review*, 50, 63 -70.
- Wolleat, P. L., Pedro, J. D., Becker, A. D. & Fennema, E. (1979). *Sex related differences in attribution in mathematics*. Manuscript in

critical Analysis of the Policy Practice of Mathematics Education in Ghana

NABIE², M. J. & KOLORAH-EKPALE P. T.

Abstract

Ensuring a smooth mathematics education programme requires the formulation and implementation of appropriate instructional policies. This study is a survey of some practices of the instructional policies and their influence on mathematics education. Completed Basic School Annual Census (CBSAC) forms and unstructured interviews were used to collect data. In the study, 2364 pupils in 33 classes and 140 teachers were involved. The study showed that instructional policies lack the consensus of those who implement them. They also lack support and monitoring. The paper recommends public debate, adequate support and a body for periodic evaluation of instructional policies at all levels.

Introduction

The aims of teaching mathematics are set within the aims of general education. To ensure quality, control, and uniformity of classroom practices, instructional policies are formulated. These policies aim at establishing a level playing ground for the implementation of the school curriculum. They may prescribe specific roles for teachers, schools, parents, and the educational authorities.

Matching teaching procedures to the various stages of development of the child is the main idea behind Piaget's theory of intellectual development (Lee, 1990). The Piagetian theory prescribes learning activities that are appropriate to children in specific age ranges, suggesting that it is not appropriate to put children with a wide age difference and with varying experiences in the same classroom to learn the same thing. In Ghana, children are expected to enter primary class one at age 6. This is to ensure that children have about the same experiences to facilitate whole class instruction.

Language is an important agent for social change and national development. The success of a nation depends on a sound language policy and a well-informed populace. It is reported that in many countries, bad language policies give rise to linguistic deficiency (Brosnaham, 1963), and inconsistent language policies lead to social tensions and educational failures (Khan, 1972). Cognisant of the fact that language barrier is a major source of children's learning difficulties; Ghana has maintained a multilingual policy on language. The language policy for instruction in basic schools in Ghana dates back as far as 1920. This policy has gone through various modifications under different ruling governments. Currently, the policy stipulates the medium of instruction for the first three years of primary education be the main Ghanaian language (L₁) spoken in the school community. English language is to be introduced and learnt as a subject from the onset of primary education, which will gradually become the medium of

² Nabie, M. J. is a lecturer in the Department of Mathematics Education, UCEW, Winneba¹ and Kolorah-Ekpale, P. T. is a Teacher Educator and works at Ghana Education Service District Directorate, Winneba.

instruction from primary class four. In order to enable teachers cope with this policy, student teachers are to study in addition to their own language one other Ghanaian language (L₁ 2) (Dzobo, 1974). In this regard, it is recommended that teacher postings should take cognisance of teachers' ability to teach in the Ghanaian language spoken in the area (The Education Reform Review Committee Report (ERRC), 1995). Generally, the policy guarantees the choice of a medium of instruction based on the majority.

Mathematics plays a leading and service role in all aspects of human endeavour. A mathematics curriculum should, therefore, provide children with stimulating and wide-range of mathematical learning experiences that will develop their skills and knowledge. This will enable them function as useful citizens. Consequently, an intended mathematics curriculum should consist of a description of all the mathematical activities that children have to experience throughout their period of schooling to achieve these objectives. However, a curriculum set within an objective-based model needs to be evaluated to help with the framing and subsequent modification of the objectives, to determine the suitability of the learning experiences, and to measure the degree to which the stated objectives have been attained (Kelly, 1989). The implementation process of the mathematics curriculum is subject to a number of variables that determine the extent to which the planned experience can be achieved. Hence, the need for checks to ascertain whether or not the planned learning experiences can produce the desired learning outcomes.

Curriculum evaluation in mathematics education involves judging the educational or instructional systems, in its entirety or in parts. It could be judging the mathematical capability, performance, and attainment of the pupils as individuals or groups that is commonly termed assessment (Niss, 1993). The ultimate aim of any form of curriculum evaluation is to provide information for decision taking. Evaluating the mathematics curriculum and assessing pupils' attainment and performance can be seen as an attempt to determine the effectiveness of the learning experiences. It provides information upon which decisions can be taken for either a change in structure or implementation of the curriculum.

It is known that a child can receive appropriate educational support if the assessment mode takes into account, and responds to, the factors that contribute to the child's learning difficulties. In this regard, Continuous Assessment (CA), a formative assessment scheme, was recommended by the 1987 education reforms. The principle of formative evaluation requires that tests are conducted in small pilot projects and the findings fed back to the team devising the innovation so that necessary changes are effected and the revised innovation tested again (Farrant, 1980). It is by this process that a curriculum and its implementation and assessment processes can be perfected and the degree to which the desired objectives achieved are determined.

The CA scheme, as a formative evaluation process, aims at obtaining a more comprehensive picture of the pupil. It is also to minimise fears, anxieties and malpractice in examinations. Techniques of this kind of assessment may include observation, discussion, tests, and project-work, among others. Its operation requires a careful, skillful administration, sensitive interpretation with a high level of professional competency, and adequate logistics for effective implementation. It is believed that the frequent causes of collapse of promising educational policies and strategies for change is the failure to provide adequate

training to those who will implement the change as well as facilities for the programme. And that 'to introduce an innovative programme to those who are required to implement it, at the stage when all is cut and dried, is to invite disaster' (Farrant, 1980: 56).

Franke and Carey (1997) points out that the nature of the classroom environment in which mathematics is taught strongly influences how children perceive the subject, how it should be done and what they consider appropriate responses to mathematical questions. A teacher who has to teach many classes a day has little time to reflect on his or her teaching and/or prepare instructional materials for alternative approaches. Also, the teacher that lacks workspace cannot develop far as 'a reflective practitioner' (Howson and Wilson, 1990). Cognisant of the importance of a manageable learning atmosphere, education authorities worldwide develop guidelines to control and regulate classroom environments for effective teaching and learning. One important policy in this regard is that of the class size. In many countries a class size is about 25-30 pupils to enable individual attention and effective teaching. In Ghana, the recommended number of pupils per class for Kindergarten is 46. Where classes fall below this number, teachers are permitted to combine classes but the total number of pupils resulting from the combination should not be more than 46 nor less than 20. At the primary level, the maximum class size should be 46 (G. E. S., 1998 appendix 1a). The question, however, is what is the impact of the national instructional policies on mathematics education? This study was designed to look at some of the current educational policies and their influence on mathematics education. Specifically, it looks at policies on age, language, continuous assessment (CA), curriculum and class-size, in relation to the effective teaching and learning of mathematics at the basic level.

Methodology

Sample

The population involved basics 1-6 pupils and teachers in the Winneba District. Schools in the district are located in communities with diverse demographic characteristics. Stratified random sampling technique was therefore used to select two schools in towns and two schools in rural villages. This was to ensure that the sample is representative of the population. The demographic characteristics of the selected schools are in appendix A. The teachers on the other hand, were selected at random.

The study was conducted in three phases and for easy analysis of data, relatively small samples were taken. In the first phase, 876 pupils from four schools in four circuit areas; two schools in towns, two in rural villages and one school from each circuit area, were drawn for the age distribution analysis. In the second phase, 1,489 pupils from 33 classes in one circuit area were examined. The last phase involved 140 primary school teachers for the language, curriculum, and CA policy analysis.

Instrumentation and Data Collection

Two major instruments were used for the study namely: the Completed Basic School Annual Census (CBSAC) forms for basic schools and unstructured interview schedules. The completed CBSAC form indicates the child's class, how many children are born in a particular year, and the total number of children in

the class. The interviews were used to determine teachers' awareness of the language policy, how they practice it in the mathematics classroom, and the volume of L₁ materials in mathematics at their disposal to support mathematics teaching. The interviews were also used to determine the various ways in which classroom teachers were involved in the mathematics curriculum design process, to confirm actual class sizes, and how teachers cope with their teaching. The nature and sequence of questions depended on the manner of response by a particular teacher.

Analysis

Data were presented in tables and for further analysis. The number of children who entered schools before, exactly at and after 6 years were converted into percentages. A simple inspection of teachers "yes" or "no" responses of the interview schedules were used to examine the level of L₁ usage and the extent to which teachers are involved in the mathematics curriculum design process. To determine the average number of pupils per class and the age dispersion of pupils in the classes, the mean and standard deviation of the class size data as well as the coefficient of variation were computed.

Results

The distribution of the years of birth of the four schools for class 1-class 4 (B1-B4) is as shown in Table 1a. The proportion of children who entered school before, exactly at, and after 6 years is shown in Table 1b.

Table 1a Age Distribution of Years of Birth in Basic one to four of some schools in Winneba District

SCHOOL	CLASS	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Totals	AGE RANGE
Town School A	1									7	54 ^b	5	66	91-93 (3yrs)
	2							4	11	55	4		74	89-92 (4yrs)
	3						2	19	56	5	2		84	88-92 (5yrs)
	4					4	31	65	9				109	87-90 (4yrs)
Town School B	1								5	11	37	17	70	90-93 (4yrs)
	2						2	7	10	27	11		57	88-92 (5yrs)
	3					2	7	11	32	19			71	87-91 (5yrs)
	4				8	6	15	31	15				75	86-90 (5yrs)
Village School A	1	1			1	7	4	11	7	3	6		40	86-92 (7yrs)
	2		1		4	7	5	10	0	2			29	86-92 (6yrs)
	3			2	5	4	6	6	7	2			32	84-91 (7yrs)
	4			1	4	4	5	7	1				22	84-90 (7yrs)
Village School B ^a	1					4	8	9	6	6	7		40	87-92 (6yrs)
	2		0	1	1	4	5	7	15	8			41	85-91 (7yrs)
	3			2	4	10	9	9	3				37	85-90 (6yrs)
	4	1		2	10	6	9	1					29	83-89 (7yrs)
Totals		1	2	8	37	58	108	197	177	145	121	22	876	

^a This school is assisted by an international organisation -PLAN International

^b The numbers shaded indicate the number of pupils who went to school at the recommended age in the class. Numbers to the left of the shaded values, indicate the number of pupils who went to school above age; and those to the right indicate the number of pupils who went to school under age.

During the period of investigation, a child who went to school at the correct age and is in B1, B2, B3, and B4 should have been born in 1992, 1991, 1990, and 1989 respectively. Table 1b shows that the town schools have relatively high proportions of the children who went to school at the recommended. A significant proportion of the children in the towns also went underage. From Table 1b, it is also evident that majority of the pupils in the villages went to school well above the age of 6.

Table 1a shows that within the period investigated, 398 (45.4%) children entered primary class one at the required age of 6 years, 90 (10.3%) entered primary one under 6 years and 298 (44.3%) began the primary education after 6 years. Surprisingly, 60 (6.8%) of the population entered primary class one when they were 5 years or more above the age of 6.

Table 1b **Proportion of children who entered school before, at, and after the 6 years**

SCHOOL	CLASS	BEFORE AGE 6	AT AGE 6	AFTER AGE 6
Town School A	1	7.6%	81.8%	10.6%
	2	5.4%	74.3%	20.3%
	3	8.3%	66.7%	25.0%
	4	8.3%	53.6%	32.1%
Town School B	1	24.3%	52.8	22.9%
	2	19.3%	47.4%	33.3%
	3	26.8%	45.1%	28.1%
	4	20.0%	41.3%	38.7%
Village School A	1	0.0%	15.0%	85.0
	2	0.0%	6.8%	93.2%
	3	6.3%	21.8%	71.9%
	4	4.5%	31.8%	63.6%
Village School B	1	0.0%	17.5%	82.5%
	2	0.0%	19.5%	80.5%
	3	0.0%	8.1%	91.5%
	4	0.0%	3.4%	96.6%

Table 2 **Teachers response on the issue of L₁ for mathematics instruction**

ITEM	RESPONSE (%)
	YES
Teachers' awareness of Language policy for instruction	100
Use only L ₁ in teaching mathematics	0
Use mainly L ₂ (but L ₁ for explanation where necessary)	100
Studied L ₁ at college	100
Studied second Ghanaian language (L ₁ 2) at college	0
Availability of L ₁ guides or mathematics textbooks in school	0

Table 2 below provides data on the practice of the language policy for mathematics instruction in schools. The problem of language goes beyond language usage. Table 2 also shows that there is no single primary mathematics guide in the local languages for use in schools. The mathematics teachers, therefore, cannot get text material in the local language to support their mathematics instruction. In a situation like this, teachers may tend to prepare their own 'texts'. They may interpret the same concepts differently and this can have damaging effect on the mathematical development of the child.

The unstructured interview of teachers who had training before the 1987 education reforms is shown on table 3: The interview sought information on their involvement in the designing, implementation, and evaluation of the national mathematics curriculum.

Table 3: Teachers involvement in curriculum design activities

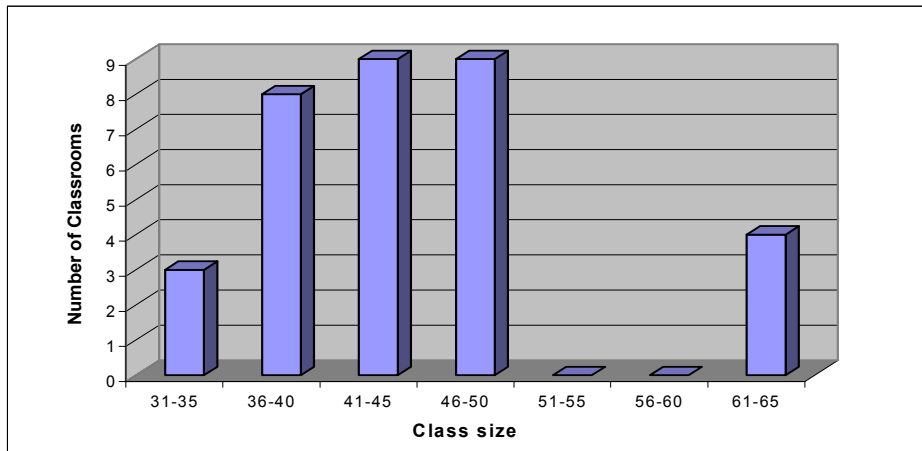
CURRICULUM ACTIVITY	RESPONSE (%)		PERIOD
	YES	NO	YES
Selection and Sequencing of curriculum content	--	100	--
Debate on curriculum before implementation	--	100	--
Pre-curriculum implementation training for teachers	1.4	98.6	1-2
Within-curriculum implementation process training	100	--	
Selection and writing text materials for schools	0.8	99.2	
<i>Evaluation</i>	3.6	96.4	
<i>Monitoring of teacher assessments</i>	--	100	--
Is C. A. marks true reflections of children's performance?	14.3	85.7	

Table 3 shows that the classroom teacher who does the bulk of the curriculum implementation is hardly involved in the mathematics curriculum process. Pre-curriculum implementation training is centred on those who do not teach in the classroom. Classroom teachers are given a week or two weeks training within the implementation period. This cannot adequately equip one to cope with demands of a new curriculum with a changed focus.

Also, teachers' responses tend to show that their CA marks cannot be relied upon for decision taking. Also, teachers are never given the opportunity to express their views nor discuss a new curriculum through debates or committees before its implementation. The tendency has been that of submitting the new curriculum to the Ministry of Education for immediate implementation as soon as a team of curriculum experts finished its job. At best a hastily pilot study is carried out at some selected schools to bless the implementation process. The views of the teachers who implement the curriculum are very important but are often ignored.

Figure 1 shows a summary of the number of children in a class for the 33-classrooms under study

Figure 1 Bar chart showing the number of children per class



Thirty-three classrooms within one selected circuit showed a total of 1,489 pupils with a mean number of 46 pupils per class, a standard deviation of 8.8 and a coefficient of variation of 19.13. Though the mean tends to agree with the recommended value, the large coefficient of variation indicates a wide variation from the mean on school enrolment. The 33 classes have a minimum of 31 pupils and a maximum of 65 pupils in a class and 4 (30.3%) of the classes have 61 pupils and above.

Mathematics teaching and learning requires a lot of space for demonstrations and self-learning activities, and one can see the wisdom in restricting the class size. The recommended class-size of 46 might be based on the average classroom space. It is however doubtful whether teachers can effectively teach mathematics to over 40 pupils in a 30-minute lesson or 60 minutes for a double period. This requires a critical study. The benefits of class-size policy cannot manifest itself in the classroom if there is no mechanism to check its implementation.

Discussion

The study shows there is a wide age gap between pupils in the same class. The practice is accepted probably for the following reasons: the need to encourage education for all, parents not knowing the exact ages of their children and the criteria for the children's school going age being the size of the child which depends on so many variables. It seems the nature of the age policy for schooling makes the time of entering school 'open' giving room for vertical groupings at all levels in the basic schools. Vertical groupings can give rise to a greater spread of mathematical attainment among the children. Matching teaching and learning activities to the needs of individual children can become difficult if the attainment and learning rate vary greatly from pupil to pupil. This is because in such circumstances, teaching at a certain level makes it difficult for some children to understand and others bored. As a result, the intended curriculum may not be covered because the classroom becomes a confused arena of age and methods conflict. Some children, especially the gifted ones, experience difficulties because the heterogeneity of the class renders their potential to be

under-used and wasted and they find themselves as able misfits. They live down to the expectation of the teachers and exhibit a variety of educational or behavioural difficulties (Harper et al, 1987). The Cockcroft Report (1982) denounced this kind of groupings because it carries no advantage in mathematics teaching and learning. The age difference of 6 and above, as in the deprived and rural villages, is too wide for meaningful classroom instruction. The confusion set by such a wide age range can reduce instructional effectiveness in classrooms because planning teaching-learning experiences becomes much difficult.

The study shows that L_2 is mostly used for mathematics instruction. L_1 is used only where communication breaks down. This practice denies children of a language with which they can comfortably communicate. Denying them access to one form of communication, a form of psychological tool, diverts their cognitive development to a quantitatively different pathway from that expected from teachers (Daniels and Anghileri, 1995). In other words language, in whatever form it may be, is a tool for mathematical dialogue and children who have no access to this tool are constrained in their mathematical development.

In contemporary Ghana where there are multilingual classroom environments, one can see the wisdom of the Dzobo (1974) Committee's recommendation of biligualism in the local languages. By Dzobo's suggestions, pupils and teachers have to learn two local languages alongside English language. Bilingual education is seen as one solution to improving educational attainment among indigenous people. However, when teachers cannot speak the language of the children, their ability to transfer knowledge is limited (Egne and Chesterfield, 1996). When children are not taught in a language they understand, all the ideas and intentions acquired through pre-school experience with which they arrive at school are ignored. This study confirms earlier studies indicating that for lack of English language facility, pupils are not even encouraged to explain their answers (Messenger, 1991), and teachers monopolising the power of class control because children lack the linguistic ability to challenge. The teacher-pupil relationship in these circumstances is characterized by 'authoritarian rigidity' (Grindall, 1972), and children are treated as empty vessels to be filled.

Majority of teachers point out that pre-training for the new curriculum implementation was concentrated on the trainer of trainers at district offices of Ghana Education Service (G. E. S). Classroom teachers receive their training within the curriculum implementation period. Training was in batches and the longest period was two weeks, which they claim was highly inadequate to equip a teacher with the necessary skills to meet the challenges of the curriculum innovations, especially, on CA and content knowledge of mathematics.

It appears there is no statutory education body responsible for the periodic evaluation of the national mathematics curriculum, or if it exists at all it is not functionally effective. The only body that teachers feel provides meaningful information about the mathematics curriculum is West African Examinations Council (WAEC) through her examination results. The major form of evaluation is the teacher assessment, which Jurdak (1993) described as suffering from psychometric deficiencies for lack of content validity, reliability, and comprehensiveness. Notwithstanding, the fate of the curriculum, what the child is supposed to learn, is left to the 'whims and caprices' of the teacher. However, since examination grades are what the society and the authorities tend to value,

a good continuous assessment mark, regardless of its authenticity, by the class teacher can do the 'trick.'

Conclusion

The instructional policies on age, language, and curriculum evaluation procedures, if effectively implemented and monitored, operate jointly to ensure a smooth mathematics education programme. The language policy ensures a level ground for the communication, understanding and development of mathematical ideas. The age policy facilitates proper instructional planning for effective mathematics teaching and learning whereas a policy on evaluation and assessment will provide information for decisions about the overall effectiveness and suitability of the mathematics education programme. However, most of these policies lack the consensus of the professionals who implement them. Though the instructional policies aim at focusing attention on the individual needs: in the curriculum, classroom, and school context, they are often not monitored. Some policies are left at the mercy of the teacher who may hardly practise them because of the real nature of the classroom. This results in learning difficulties for the pupils and tensions among the policy makers, parents, and teachers. The study did not look at how teachers manage their classes under such operational policies. This would be an interesting topic for further study.

Suggestions

For these instructional policies to have a meaningful impact in the mathematics classroom, they either have to be appropriately supported, reviewed or enforced by policy makers.

While encouraging education for all, creating wide age-gaps should not be encouraged. There is the need to provide the necessary education and logistics for birth registration. This will provide accurate bio-data of children to ease instructional planning and teaching. The structure of the classrooms suggests that curriculum differentiation, whereby children learn at their own pace that commensurate with their experiences, should be encouraged. There should also be provision for remedial teaching in schools to support children with learning difficulties.

To support the language policy, for example, the bilingual policy of learning two local languages should be reconsidered seriously in our Initial Teacher Training Colleges (ITTCs). It is only when the teacher knows the dynamics of a language that he or she can use it for instructional purposes, especially in mathematics. If the current language policy cannot be reviewed, then Day Nurseries should be established countrywide to cater for the English language needs of pre-school children before they begin primary one. Also, provision should be made as matter of urgency, for mathematics textbooks to be written in the local languages for basic schools. The University College of Education of Winneba can be charged with these responsibilities.

In future, policy makers should ensure that teachers receive sufficient pre-training in all aspects of a curriculum innovation before the implementation process to avoid gambling with the young on which the future of the nation rests. Though the curriculum developer might be an expert, there is always the need to subject their proposals for critical analysis before their implementation. Curriculum debates or submissions are crucial for a smooth implementation.

Also, a vibrant external body for periodic evaluation of the national curriculum (intended, implemented and attained) is very essential. Through the operations of this body, the curriculum innovation process can be perfected. External examinations should be conducted, especially, at primary six and throughout the JSS classes to assess pupils' attainment until things are normalised. These examinations will provide uninterrupted data about the curriculum, check teachers and their teaching behaviours.

Finally, in making policies pertaining to classroom mathematics instruction the Mathematical Association of Ghana (MAG) should be fully involved.

References

- Brosnahan, L. B. (1963). Some historical causes of language imposition. In *Language in Africa*, J Spenser (eds.). London: Cambridge University Press
- Cockcroft, W. H. (1982). *Mathematics Counts*. London: HMSO
- Daniels, H. and Anghileri, J (1995). *Secondary Mathematics and Special Educational Needs*. London: Cassell
- Dzobo, N. K. (1974): The New Structure and Content of Education for Ghana, Ministry of Education. Accra
- Egne, R. J. & Chesterfield, R (1996). Bilingual education and students performance in Guatemala. *International Journal of Educational Development*, 16 (3), 291-302
- ERRC (1995). Report of the Education Reform Review Committee. Ministry of Education, Ghana
- Farrant, J. S. (1980). Principles and Practice of Education. Essex: Longman Group
- Franke, M. L. & Carey, D. A. (1997). Young children perception of mathematics in problem solving environments. *Journal for Research in Mathematics Education*, 28 (1), 8-25
- G .E. S. (1998). Seminar/ Workshop for District Key Officials and Community Leaders- Cape Coast.
- G. E. S. (1988). Mathematics Syllabus For Primary Schools. CRDD, Accra
- Grindall, B. T. (1972). *Growing up in two Worlds. Education and Transition among the Sisaala of Northern Ghana*. New York: Holt, Rinehart & Winston Inc.
- Harper, G., Laing, A., & Chazan, M (1987). Teaching Five to Eight Year-olds. Oxford: Blackwell
- Howson, G. and Wilson, B (1990). *School mathematics in the 1990s*, (A. G Howson & J. P. Kahane eds.) *ICMI Study Series*. Cambridge: Cambridge Univ. Press.
- Jurdak, M. (1993). Assessment in mathematics education in Arab countries. *Cases of Assessment in Mathematics Education. An ICMI Study*. M. Niss (ed.). Dordrecht, Kluwer Academic Press. 35-41
- Kelly, A. V. (1989). The Curriculum Theory and Practice (3ed.). London: Paul Chapman Pub.

- Khan, Z. (1972). Language, Education, and National development. *Issues in Nigerian Education*. T. A Adedaja et al (ed.) Vol. 1 Nigeria: Text & Leisure Pub. 208-217
- Lee, V. (1990) (ed.). *Children Learning in School*. London: Hodder & Stoughton.
- Messenger, C. M. (1991). The language issue in Lower Primary Mathematics teaching in Ghana. Unpublished M. Ed.. Dissertation, Univ. of Leeds, Leeds
- Niss, M. (1993). Assessment in mathematics education and its effects.. Investigations into *Assessment in Mathematics Education. An ICMI study*. Dordrecht, Kluwer Academic Press, 1-29
- Orton, A (1994). *Learning Mathematics*. London: Cassell.

Appendix A Demographic Characteristics of Selected Schools

CIRCUIT AND SCHOOL	CHARACTERISTICS OF SCHOOL LOCALITY
Town School A	A town with a University College, secondary school and many basic schools. A few are government employees, but the natives are basically fisher folks and traders.
Village School A.	The village shares borders with the E/R and Agona District. The school is the farthest from the district office. It is at the extreme northwestern part of the district. The rural town was a business centre during the colonial times but collapsed after the aliens' compliance order. Inhabitants are mostly traditional farmers. They are industrious and education-minded.
Village School B*	A deprived rural village with populated school. Inhabitants mostly farmers and traditional healers and fetish priests. The school is PLAN International assisted
Town School B	Situated in a declining town and populated student-wise. Inhabitants are business oriented-mostly fishermen and fishmongers

Mathematical Model for Water Quality (Portable Water): A Case Study

DONTWI, I.K., NUAMAH, N.N.N.N., & AWUDI, G³

ABSTRACT

A water quality model for water-use-goal is proposed. The model is tested with a treatment schedule at a water works for portable water. It was observed that at least a 25 per cent savings can be achieved if the model is employed.

Introduction

The use of mathematical model is finding its use in the area of many real life problems. The field of management is not an exception. The water-use-goal of water in any of its forms is a rather multi-facet problem. Water for agricultural purposes must be such that it will not have any adverse effect on the produce. In the same way, water quality for industrial purpose say for a soap factory will be different from that of a car washing centre. If we have to have portable water then this water must be of a certain quality. The quality of water will depend on various set standards. These standards may be locally or internationally specified. For portable water extra care is taken such that public health practices are met.

In Ghana the water treatment industry aims at employing treatment inputs in order to achieve targeted final water quality of specific standard. It is expected that needed experiments will be performed to analyze raw water for the inputs quantities so as to meet the prescribed quality. It is realized that most treatment plants do most of the input measurements by experience. In other words measurements are known to have worked and therefore will work. In these circumstances non judicious use of materials is very likely to occur. The resulting effect could be a waste to a large extent. This, therefore, will not give a cost effective schedule.

To address the problem of rational use of treatment inputs at an optimal cost Management Mathematical Methods (MMM) could be used. The

³ Dontwi, I.K (Ph.D), is a lecturer in the Department Of Mathematics, Kwame Nkrumah University Of Science And Technology, Kumasi, Ghana; Nuamah, N.N.N.N. (Ph.D) also lectures in the Institute Of Statistical, Social And Economic Research, University Of Ghana, Legon, and Awudi, G, is a lecturer in the Department Of Biological Sciences, KNUST, Kumasi, Ghana.

advantage these methods have over the traditional experiment is that we simulate to arrive at the set goal as long as we are able to mimic the real-life situation. Even in its simplest form the model could be used to have an insight into the problem in question. In the forgoing we calibrate the model.

Model

We consider the cost function $F(x)$. This is the functional representation of activities involved in the treatment schedule at the plant. The objective would be to operate at a minimum cost.

In the operations treatment is done systematically at various stages. It is expected that certain specific standard will be attained in order to have the required quality for the domestic use. To this end, each input will be constrained to meet the required standard.

The above simplified problem is a typical Linear Programming Problem in Management Mathematics and can be formally formulated as:

$$\min F(x)$$

Subject to the constraints

Specifically,

$$\min F(X) = \sum C_i X_i, \quad i = 1, \dots, n;$$

Subject to the constraints

$$L_j \leq \sum A_{ij} X_i \leq U_j, \quad i = 1, \dots, n; j = 1, \dots, m;$$

$$0 \leq X_i \leq T_i, \quad i = 1, \dots, n.$$

Where

A_{ij} technical coefficients indicating the extent to which a parameter j of interest in a unit volume of water is affected by a unit quantity of treatment input, i applied during treatment.

X_i - unit quantity of treatment, i to apply at treatment stage i to treat a unit volume of raw water per month.

C_i unit cost of treatment input i .

L_j minimum desirable level of parameter j sought in treated water after treatment.

U_j maximum desirable level of parameter j in treated water after treatment.

T_i maximum allowable quantity of treatment input i to apply per unit volume of raw water so that treated water after treatment is not re-contaminated.

The A_{ij} 's were obtained using the plant control testing data and the treatment input consumption data.

The L_j 's and the U_j 's were calibrated using the plant control testing data and the targeted desired water quality after treatment.

T_i 's and C_i 's are constants.

Two main problems are considered corresponding to the two major seasons in Ghana that is the wet and Dry Periods. In both periods the mean monthly problems are considered. The method of solution is the standard Simplex Algorithm which is implemented on the computer to solve both problems. For each of the major problems a sensitivity analysis is performed to determine the least and the highest costs possible per month to achieve the desired water quality after treatment for a unit volume of water. This is done with a 95% certainty.

Results and Discussion

The mean monthly optimal cost has been determined together with the least and highest possible cost found by the sensitivity analysis (Awudi 1999). These results are summarized in Tables 1 & 2.

Table 1 *Wet Period Mean Monthly Optimal Cost*

	Least	Mean	Highest
Alum in bags of 50kg	2486.0	2489.0	2492.5
Back-washing water in Drums of 1000 gallons	9000	9000	9000
Lime in bags of 50kg	398.0	449.0	516.5
Chlorine in 1000kg Drum	3.38	3.45	4.25
Total cost in million cedis	77.7	78.7	81.2

Table 2 *Dry Period Mean Monthly Optimal Cost*

	Least	Mean	Highest
Alum in bags of 50kg	2264.5	2266.5	2269.0
Back-washing water in Drums of 1000 gallons	9000	9000	9000
Lime in bags of 50kg	543.5	550.5	612.5
Chlorine in 1000kg Drum	2.95	2.97	3.50
Total cost in million cedis	74.0	74.2	76.1

Associated treated water quality:

- colour ≤ 5 TCU
- $7.5 \leq \text{pH} \leq 8.0$
- $0.3 \text{ mg/l} \leq \text{Residual Chlorine} \leq 0.5 \text{ mg/l}$ after 30 minutes of contact time

The unit volume of raw water used is 330 million gallons.

It was observed that for a unit volume of 330 million gallons of raw water abstracted and treated the overall monthly average was close to the 100 million mark whereas the model is giving almost a 25% saving based on higher portable water quality standards proposed by WHO (1971).

Conclusion

The Management Mathematics Methods have been successfully employed in the management of portable water. The effectiveness and efficiency of the procedure cannot be over emphasized. The savings thereof could be used to improve other aspect of the end use of water.

Further work is to be carried on in order to refine the model thus making it more user-friendly.

Reference

- Awudi, G. 1999) *An Optimal Model For Targeted Water Quality After Treatment: A Case Study Of Barekese Water Headworks*. M.Sc. Thesis (Department of Biological Sciences, Kwame Nkrumah University of Science & Technology, Kumasi, Ghana.
- James, A. (1984). *An Introduction to Water Quality Modelling*. John Wiley & Sons, Great Britain.
- World Health Organization (1971). *International Standard Methods For Drinking Water*, 3RD Ed. Geneva: WHO.
- Rand, M.C., Greenberg, A.E. and Taras M.J. (1976). *Standard Methods For The Examination Of Water And Wastewater*. 4TH Ed. Washington, D.C: American Public Health Association.

Basic School Pupils' Strategies in Solving Subtraction Problems

OKPOTI⁴, C. A.

Abstract

This article reports some of the strategies basic schools children apply in solving subtraction problems. The purpose of the study was to see whether the semantic structure of mathematical problems influences children's choice of strategy in solving a subtraction problem.

Introduction

A problem is a challenging question or statement presented in such a way that learners accept the change. Problem solving therefore is the process of accepting a challenge and striving to resolve it. In mathematics it involves the solution of storey problems which describe real or imaginary events and which requires the application of computation skills, concept of time, measurement, money, geometry, etc to solving it.

In the learning and teaching of mathematics, 'problems' can be used in the mathematics classroom to assess pupils' understanding of topics taught. Certain problems can also be posed during the lessons with the aim of calling on the learners to participate or pay attention. Frobisher (1994) however pointed out that not every question posed in the classroom is a mathematical problem. The commonly accepted view of a mathematical problem is the 'word' problem. He therefore, defined problem as a task presented in words with a question posed to define the goal a solver is expected to attain in carrying out the task.

Earlier on, Sowder (1985) termed questions that are not posed in words as exercises e.g. $1 - \frac{2}{5} = \square$.

In supporting, Sowder (1985) and Butts (1980) classified exercises into two groups – recognition and algorithmic exercises. Examples of the two categories of exercises for lower primary are presented in Boxes A and B.

Recognition Exercise

Which of the following is a linear equation.

(a) $2 + 3 =$

(b) $5 - \square = 3$

Box A

⁴ Okpoti C. A. is a lecturer in the Department of Mathematics Education, UEW

Mathematical problems may also be classified as *routine* and *process* problems. Solving of a routine problem calls for direct application of previously learned algorithms or operations after the words have been transferred into

<p style="text-align: center;"><i>Algorithmic exercise</i></p> <p>(a) $14 + 7 = \square$</p> <p>(b) $\begin{array}{r} 25 \\ \times 3 \\ \hline \end{array}$</p>

symbols (LeBlanc et. al, 1980; Frobisher, 1994). The popular traditional or textbook word/story problems can be classified under this group. Unlike the routine, process problems require the use of strategies or non-algorithmic approach. It focuses on the processes or methods of achieving the solution rather than only the final answer (LeBlanc et al, 1980).

What a problem solver desires to achieve is the goal, but this goal cannot be achieved easily. According to Kahney (1986) a problem arises whenever a goal may be blocked by reasons such as lack of resources, lack of information and so on. The basic characteristics of problems have been identified. Mayer (1983) in his submission itemised the basic characteristics as the *givens*, the *goals* and the *obstacles*. He defined these as follows:

The Givens– are the information/data about the initial state of the problem.

The Goals – refer to what the solver is expected to achieve.

The Obstacles – may be considered as restrictions of transferring or changing the givens' to achieve the desired goal.

Therefore in order to be able to solve a problem these characteristics of a problem which will enhance the solving of the problem correctly should be identified.

Studies have shown that word problems are difficult for children of all ages and that children master symbolic addition and subtraction operations before they can solve simple word problems (Carpenter and Moser, 1982).

Methodology

A *written test* was set to investigate whether the semantic structure of language could suggest to pupils an appropriate strategy to solve a problem. That is, questions for the test were designed in such a way that the structure of the language (semantics) could suggest to the solvers (pupils) an appropriate strategy to solve a problem. The questions were expected to have the same results, even though pupils were expected to employ different strategies or methods depending upon their understanding of the problem. *Interviews* were used to find out how the pupils approached the questions and the strategies they employed in solving them.

The following questions were used to investigate the children's understanding of the semantic structure:

Twenty-five pupils in primary Class Five from the University Practice Primary School in Winneba were interviewed on the strategies used in solving the problems.

Results

It is interesting to note the kind of understanding children demonstrated on the various word problems. The problems made the children to use different brilliant strategies in their solutions. The pupils' solutions are considered next.

An important measure of the child's success at problem solving is the evidence of understanding the problem and by using the appropriate problem solving strategy.

The Table 1 gives the number of pupils obtaining correct answers in the three questions and Table 2 shows the total score obtained out of 3 by the pupils.

Table 1: *Pupils obtaining correct answers in the three questions*

	Number of Pupils obtaining Correct Answer	Percentage of Pupils obtaining Correct Answer
Question 1	17	68%
Question 2	18	72%
Question 3	15	60%

Table 2 *Total score obtained out of 3 by the pupils*

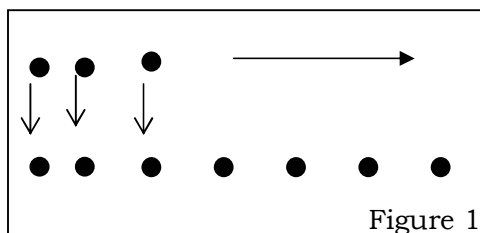
Mark obtained out of 3	Number of Pupils obtaining mark	Percentage of Pupils obtaining mark
0	4	16%
1	0	0%
2	3	12%
3	18	72%

Comparison Problem

Question 1 is a comparison problem. In this question, 17 out of the 25 pupils (68%) had correct solution. 12 out of the 17 pupils who had it correct used the *matching strategy* in solving it. The other 5 simplified it as $7-3 = 4$ which is the correct answer to the problem.

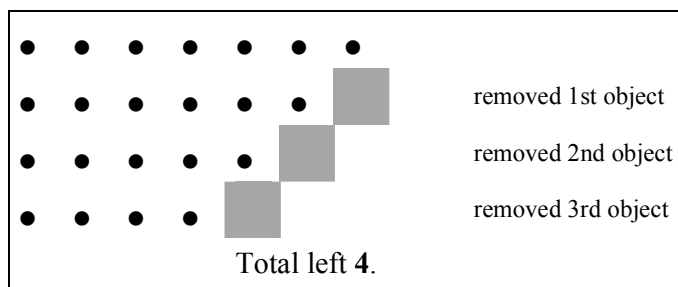
The Matching Strategy

The children obtaining the correct solution here formed a set of 3 objects and another of 7 objects. Then the two sets were matched one to another by placing the objects of the sets in one-to-one correspondence. The excess of the larger over the smaller, that is, the unmatched objects, were then counted to determine the answer. The strategy employed by the children is illustrated in Figure 1.



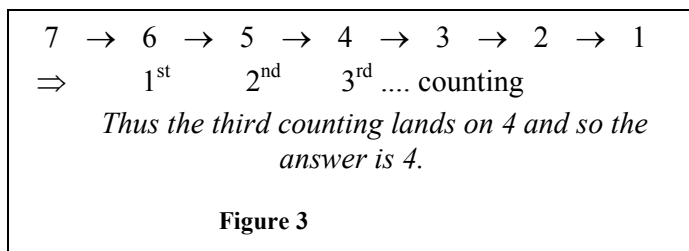
It is important to note that, this strategy acknowledges the relationship between two disjoint sets. 72% of the children successfully answered this question. It seems to be the easier among the three questions, because of the "take away" element of the problem. It worth noting that all the pupils

who had this question correct used the same strategy (the separating strategy).



The child removed three objects, but removed one object after the other.

Figure 2



removed from this model set, one at a time as the children count. They removed 3 objects from the set of 7 objects and then counted the objects in the remainder set to determine the answer.

The separation strategy employed by the children is illustrated in Figure 2.

The number of objects left after the 3 objects are finally removed is 4 objects. This explains that after Ebo has given 3 of his 7 oranges to Abena, he was left with 4 oranges, which answered the question.

Adding-on Strategy

In Question 3 some pupils used the adding on strategy. From Table 1, 60% of the pupils had this correct. That is, 12 out of the 15 pupils who answer 3 correctly used the adding - on - strategy. The other 3 pupils used an algebraic approach

($3 + a = 7, \Rightarrow a = 4$) in solving question 3.

The additive action structure embodied in this problem was reflected in the use of the addition strategy which we call 'adding on'. Twelve (12) children started by counting out a set of 3 objects. Then the objects in the set are increased by the addition of objects, one at a time, until a set of 7 objects

was obtained. The answer was determined by counting the number of toys added onto the original set. The adding-on strategy employed is illustrated in Figure 3.

The number of objects added to 3 objects to make 7 objects is 4. So Oforiwa needed 4 more toys to add to the 3 toys, if she needed to get 7 toys. From Table 2, it can be noted that 16% of the pupils could not solve any of the 3 problems, however, 72% of the pupils solved all the three questions correctly.

Discussion and Conclusion

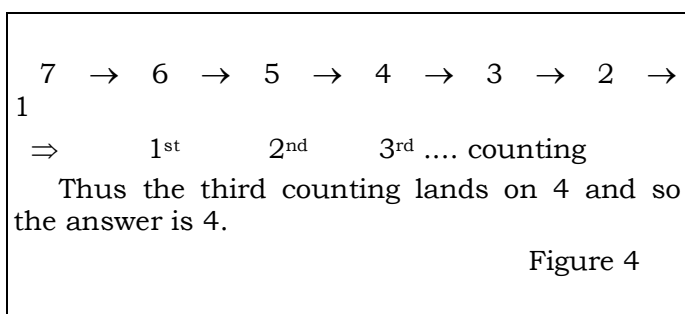
Counting-down Strategy

When considering all the problems stated in different forms, which involve the difference between 7 and 3, the children can use simpler counting strategy to arrive at the solution. The simpler counting strategies are counting down (counting backward) and counting up (forward counting).

The internal counter is set at 7. Then from 7, it is counted backward 3 times. The last numbers to call at the end of the third counting is the answer. This strategy employed is illustrated in Figure 4.

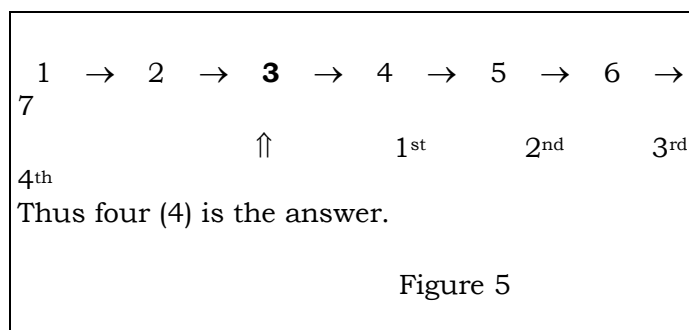
Counting-up Strategy

In this case the internal counter is set at 3, and then increments by ones are made until the counter reads 7. Counting the number of increments (that is, the numbers of counting words spoken) gives the answer. The last strategy employed is illustrated in Figure 5.



Children using the physical objects to model a problem and solve it can then enter into a more sophisticated approach of counting by using a memorised sequence of counting.

Children can start the counting from any number other than 'one' and count forward (counting-up strategy) or backwards (counting-down strategy), and



stop the counting appropriately to obtain the required answer.

The counting sequence strategy was used more than the other strategies in the subtraction word problems, especially the counting up strategy which seem very easy for them. The

choice of the children to use the counting-up (forward) strategy, is another example to show children's good problem solving ability. In general, the large majority of successful young problem solvers used some form of counting (Gelman and Gallistel, 1978).

It was also observed that most of the children understood the language (semantic). The children's knowledge of the language assisted them to adopt appropriate strategies to get the required results. This may also show young children's ability in solving problems.

Although the research has shown some incidence of successful problem solving performances by primary age children, this should not give the reader a false conclusion that all children are good at solving problems. However, experience has shown that when children are given the appropriate approach of teaching mathematics they can demonstrate some good problem solving abilities.

Recommendations

The following can be considered to enhance children's 'word' problem solving ability:

- (i) There should be a general practice of asking questions in word/story form. The teacher should read or explain the question to the children who cannot read well. The practice of just writing ' $5 - 3 =$ ' for children to solve may not expose different strategies which are endowed in the children.
- (ii) The language used should be at the level of the children. This means that the children should understand words or phrases used in constructing the problem.
- (iii) When a problem is given, the teacher should be patient and give children time to think of their strategies.
- (iv) The teacher should assist children, who are finding it difficult to think of any strategy, with a 'leading question' to enable them come out with strategies that may assist in arriving at the solution.
- (v) Complex sentences can affect children's comprehension of a problem. Use of short or abbreviated sentences may facilitate the understanding of the problem.
- (iv) The numbers involved in the problem should be such that children would be able to manipulate.
- (v) Children should cultivate the habit of evaluating their own ideas and strategies.
- (vi) Mathematics textbooks in the Basic Schools should be written to favour the teaching of word problems.
- (vii) The mathematics textbooks should be sufficient to enable every child to have access to one. This may encourage children to read on their own and form ideas on a problem read before coming to the classroom.
- (viii) Assessment, whether internal or external, should lay more emphasis on process-oriented questions.
- (xi) The curriculum should be designed to encourage the teaching of problem solving or strategies to tackle a problem.

References

- Butts, T. (1980) *Posing Problems Properly*. In Krulik, S. and Reys, R.E. (ed). *Problem Solving in School . Mathematics*, NCTM 1980 Yearbook.
- Carpenter T.P. and Moser J.M. (1982) Young Children are Good Problem Solvers, In the *Arithmetic Teacher* Vol. 30, Number 3

- Frobisher, L. (1994) Problems, Investigations and Investigational Approach. In Orton, A. and Wain G. (eds). *Issues in Teaching Mathematics*, London: Cassell.
- Gelman, R and Gallistel C.R. (1978) *The Child's Understanding of Number*. U.K. Cambridge.Mass Howard University Press.
- Kahney, H. (1986) *Problem Solving. A Cognitive Approach*. England. Open University Press.
- LeBlance, J.F, Prodfit, L and Putt, I .J. (1980) Teaching Problem Solving in the Elementary School. In Krulik, S. and Reys, R.E. (ed). *Problem Solving in School in School Mathematics*, NCTM 1980 Yearbook.
- Mayer R.E. (1983) *Thinking, Problem Solving, Cognition*. New York U.S.A. W.H. Freeman and Company
- Reys R.E. et al (1980) Results and Implications of Mathematics Assessment for Elementary Schools. *Arithmetic Teacher Vol. 27*.
- Sowder, L. (1995) Cognitive Psychology and Mathematical Problem Solving. A Discussion of Mayer's Paper. In Silver, E. A. (ed), *Teaching and Learning Mathematical Problem Solving. Multiple Research Perspective*. New Jersey, U.S.A.: Lawrence Erlbaum Associates, Inc.

Helping Students Overcome Mathematics Anxiety

AWANTA⁵, E. K.

Abstract

The main thesis of this article is that relationship between anxiety and the learning of mathematics is complex. Anxiety as a form of arousal, of alertness, of paying attention can be helpful in learning. But too much anxiety, especially when combined with real or perceived lack of ability or complicated by distractions, can seriously hinder learning. “Any of you who has taught a course in mathematics has surely sensed the anxiety that permeates the classroom during the first few class sessions”, Runyon (1977) comments. The sense of foreboding is not in the least lessened by the students’ first glimpse of the textbook, replete with strange and incomprehensible hieroglyphics and ponderous verbiage. In fact, in my experience most withdrawal (psychological as well as physical) occurs during this first week. The article intends to outline causes of these strong negative feelings about things mathematics. It also suggests cures for mathematics anxiety.

Introduction

The presentiment about anything mathematical might be regarded as a specific form of mathematics anxiety. The attention given to mathematics in the past has furnished evidence, both anecdotal and statistical that many people prefer to avoid mathematics. Still more devastating, the illogical fear of mathematics often creates a block that prevents the learner from mastering the subject.

Mathematics anxiety manifests itself in persons who are uncomfortable in the world of representative samples and data analysis. A case in point is the situation in which a highly competent professional lady teacher, who was admitted into the mathematics education department of the University College of Education of Winneba (UCEW), to pursue the mathematics education programme, admitted dreading mathematics. She had to switch her college major from Mathematics to English.

More formal evidence of negative feelings about mathematics was obtained from a questionnaire I gave to my educational research class. At the beginning of the course, students were asked to describe their expectations concerning mathematics.

Although a few felt it would be a “breeze”, majority of the students expressed various degrees of distress. Their fears seemed to cluster around three general areas:

- ◆ Uncertainty about the adequacy of their background in mathematics;

⁵ Awanta, Ernest K. is a lecturer in the Department of Mathematics Education, University College of Education of Winneba

- ♦ Unspecific rumours and “horror stories” spread by others who had taken mathematics as a course; and
- ♦ The dread of having an impatient teacher. (There is the general agreement among the students that the competence and patience of the teacher are among the most powerful determiners of success for those who fear mathematics).

In another instance, interviews I conducted with some of the first year Bachelor of Education students of the University College of Education of Winneba, who have been recently introduced to Core Mathematics – a general course – indicate that they are taking the course against their wish. They vehemently protested against it. A group of the students offering accounting even temporarily abandoned the course.

Causes of Fear

Widmer and Chavez (1982), asked, “What lies at the root of strong negative feelings about things mathematical?”

The exact philosophy of causation may never be known, but several factors play a role.

Lack of preparedness

Although students have had several years of mathematics training by the time they reach college, many view the subject as nothing but isolated facts and rules to be memorised. As the facts and rules increase, so do the students' confusion; correspondingly, their chances of doing the “right” thing rapidly diminish. I am not speaking here of students who do not know the fundamentals of arithmetic. Obviously, anyone who cannot operate with negative numbers or decimals is going to have a miserable time with mathematics. The concern here is that the student who knows basic mathematical facts and can perform basic operations has no idea of the overall structure of mathematics. In Piagetian terms, such students are not ready to assimilate college mathematics and first must modify their mental schemata (their method of organising knowledge). They must look at data and inferences in a new way. But the prospect of abandoning old approaches, even unsuccessful ones, is threatening and many resist the process.

The plight of such students is described by Skemp (1973), a mathematician and psychologist, believes that students “organise what they learn in some way”. But those who organise mathematics as discrete pieces of information sooner or later come to grief. Mechanical, and often inaccurate, rules such as “Get all the X's on one side and the numbers on the other”, do not afford the student good reasoning.

The fault, Skemp believes, is probably not the students'; Rather, the faulty schemata they have formed are more likely a result of the poor teachers they have encountered in classrooms along the way.

Conditioning

It has been established that we learn fears and anxieties, likes and dislikes, by association. Thus, much anxiety regarding mathematics may be Pavlovian in nature. Perhaps, long ago when our present college students were in elementary school, mathematics meant frustration, tension, failure, and punishment. If students approach mathematics and statistics with these associations, some attitude changes will be necessary.

Expectations

Expectations of teachers and students alike are powerful determiners of success or failure in learning. Thus, the common belief that women are less successful than men in things mathematical creates an automatic barrier for mathematics learning. Although many of the college students are eventually successful, they are more likely to be victims of the “mathematics is a male domain” myth than are more recent senior secondary school graduates. Younger students, however, still report that, some counsellors and teachers in their schools, as well as parents, convey the message that mathematics is more appropriate for boys.

Cures For Mathematics Anxiety

Understanding the causes of stress is helpful, but finding successful strategies to assist students is the key to eliminating anxiety. Here are a few techniques:

Emphasise understanding

If it is the student’s mental disarray that is causing trouble, it will be helpful to expose mechanical rules such as “Bring it to the other side and change the sign,” for what they are : misstated and misleading shortcuts. The students must be helped to understand principles such as the necessity of maintaining equality and the simplicity of “doing the same thing” to both sides of an equation.

Interpolate routines

Students’ disorganisation promotes anxiety, which hinders the formation of new concepts and schemata. Skemp believes that reflection, an activity of intelligence, is paralysed under anxiety. He suggests the interpolated routine as a way to restore helpful intellectual functioning. This routine consists of a simple task, which the students feel confident about performing. I tried this approach successfully in the statistics portion of the research methods course of both diploma and degree/post diploma classes at UEW. For example, students faced with the formula

$$SD = \frac{\sqrt{\sum_{i=1}^N (x - \bar{x})^2}}{N}$$

often feel panic. However, when it is pointed out that the first thing to be done is simply to find the average of a set of numbers, many students are able to proceed quite happily. Or, if “finding an average” is not in the student’s repertoire, the initial task can be given in terms of finding the sum of a set of numbers. Success in a simple task can then interrupt the cumulative effect of anxiety, permitting the student to resume the more difficult task in a more productive state.

Counter condition

If aversive conditioning has taken its toll, counter conditioning may be useful. Some effective informal techniques can help to build a positive attitude towards the self and mathematics. For example, because students need to experience success, especially in a subject that frightens them, it is best to administer brief, frequent quizzes rather than lengthy examinations. This allows students a better chance to show mastery.

Encourage students to use calculators to avoid excessive time and careless errors in computations. Skill in the basic operation is not necessarily the focus of any mathematically inclined course.

Extend praise for success and efforts. Even University students appreciate the equivalent of a 'smiley face' on their papers.

More formal desensitisation techniques can also be used. Kogelman and Warren (1978) developed a series of workshops in which the participants progress from talking about their experiences with mathematics to writing down feelings when faced with a mathematical problem to examining materials and devising approaches to problems. One student, who had progressed through four workshops, expressed her increased confidence by saying, "I feel I have progressed as an individual because I have taken on something I didn't know how to do before. I am no great mathematician, but now I am willing to try things".

Self-help materials in the form of tapes and workbooks aimed at the reduction of test anxiety assist users to examine feelings about tests, probe the causes behind their feelings, learn muscle relaxation's and conduct counter conditioning activities for test situations.

Some mathematics textbooks are geared to desensitise students by avoiding symbols and technical terms in the early chapters. Gradually, formulas are introduced and then topics such as "integration techniques" in calculus, say.

Use supportive teaching techniques

As I indicated earlier, one primary key to overcoming anxiety is a competent teacher who communicates to students the expectation that they can succeed. Sufferers of mathematics anxiety at all levels comment on teachers who made them feel stupid, who "put them down," perhaps unintentionally – "My ten-year-old son can do this". And they remember fondly those teachers who enabled them to believe they could learn and competently helped them to succeed. Such a positive approach may be fostered in a variety of ways.

Suggestions

The following suggestions, gathered from my experience in teaching and counselling mathematics anxious students and from the testimony of others, have been used to advantage:

- ♦ *Project the conviction that the content is useful.*
- ♦ *Encourage divergent thinking.*

Note that emphasis on right answers has benefits, but may also result in panic when that answer is not at hand and lead to "premature closure". Students who get the right answer quickly, close their book, and do not continue to reflect on the problem will not find other ways of solving it and will therefore miss an opportunity to add to their array of problem solving methods.

- ♦ *Recognise the role of intuition, self-awareness, and unconscious work in learning*

Mathematics anxious people frequently seem unable to trust their intuition. Either they remember the right formula immediately or they give up. Mathematics, like any other creative endeavour, is done partly unconsciously. Repeatedly looking at a problem or concept, going away from it, and returning to it, allows the mind the time to assimilate ideas.

- ♦ *Be tolerant of the verbally oriented person.*

Advanced verbal skills actually intensify problems in learning mathematics for some people. Specialised uses of words such as "of" to indicate multiplication, "independent" and "significant" can be confusing to the mathematically uninitiated. Considerable attention needs to be directed to

the special language of mathematics and to learning how to read mathematics in a very different way than one reads other content.

♦ *Avoid too fast a pace in learning.*

Bloom (1968), presents evidence that most students can master mathematics if time is controlled appropriately. However, mastery can be a problem in a course in which time for the mathematics period is limited to a few short weeks. Almost all mathematics anxious students have real problems with feeling rushed, especially on tests.

♦ *Allow mathematics by committee.*

It has been found that students in mathematics clinic work well in groups. Teachers who have used the committee method report that students in such groups develop confidence and study skills and thus are more successful in mathematics learning, and finally but not the least

♦ *Foster a positive climate.*

Mathematics can be used in an entertaining fashion. An occasional play on words, prizes for completing difficult problems, all can help students approach mathematics learning without the paralysis of fear.

References

- Bloom, B. (1968). "*Learning for Mastery*". *Evaluation Comment for the Study of the Evaluation of Instructional Programmes*. Los Angeles: University of California at Los Angeles Press.
- Chavez, A. Widmer, C. (1982): "*Math Anxiety: Elementary Teachers Speak for Themselves*", *Educational Leadership* 39: 387-88
- Kogelman, S. and Warren, J. (1978): *Mind Over Math*. New York: McGraw-Hill
- Runyon, R. P.(1977): *Winning with Statistics* (Reading, MA: Addison-Wesley)
- Skemp, R. (1973). *The Psychology of learning Mathematics* (Baltimore, MD: Penguin Books Inc.)

Mathematics Teachers' Knowledge of the Subject Content and Methodology

ASIEDU-ADDO⁶ S. K. & YIDANA I.

Abstract

This paper discusses the need of the mathematics teacher to be equipped adequately in the content areas in mathematics, vis-a-vis the recent concerns about the poor performance of students in the pre-tertiary schools, and the competence of mathematics teachers in the field. The low performance in mathematics at the pre-tertiary level of the education system could be attributed to the low content base of teachers of mathematics. This paper discusses ways of addressing this problem.

Introduction

In the entire history of education, mathematics has held its leading position among all other school subjects because it has been considered as an indispensable tool in the formation of the educated man. According to Griffiths and Howson (1974), "the educated man is the knowledgeable man, trained to approach the affairs of his daily life with some sense of detachment and objectivity and to reason about them soberly and correctly." Mathematics is the means of sharpening the individual's mind, shaping his reasoning ability and developing his personality, hence its immense contribution to the general and basic education of the people of the world.

The poor performance in mathematics in Ghana came to light in 1992 when a criterion reference test (CRT) which was conducted for pupils in basic schools throughout the country showed that their competence in numeracy was low. However poor performance in mathematics at the basic level in Ghana started as far back as 1980s when many teachers in search of greener pastures left the country for Nigeria and some West African countries. The classrooms became empty to the extent that in some schools, only one or two teachers remained to man the affairs of the school. Consequently, students to their disadvantage missed many mathematics periods on the timetable. This era as well saw the influx of untrained teachers into the field to replace the energetic professional teachers who had left. These untrained teachers knew very little about the methodology and content and therefore could not handle subjects like mathematics effectively. They adopted instrumental approach to the teaching of the subject and in the process, many of the important mathematical concepts were wrongly taught. The downward trend of performance in Mathematics, English and Science in recent years is a source of worry not only to parents but also to

⁶ Asiedu-Addo S. K. & Yidana I. are both lecturers in the Department of Mathematics Education, UCEW

the Teacher and all beneficiaries of and stakeholders in Education in the country. This poses a challenge to us to find factors that influence such poor performance.

Government identifies lack of access, poor quality of teaching and learning and economic constraints as the main problems our educational system is facing. We as

Teachers cannot do much about lack of access and funding of education. As regards to poor quality of teaching and learning, many factors can be found which contribute to it. Some of these factors are:

- poor attendance of students
- unconcerned attitude of parents towards their wards on educational matters
- teacher-parent confrontation on the discipline of their wards
- poor method of teaching
- lack of teaching/learning materials
- low content base of the teacher in his/her subject area.

The school, in conjunction with the local Parent-Teacher Associations (PTA) must address the problem of poor attendance of pupils and students and the unconcerned attitude of parents towards their wards. The teacher does not cause this problem largely. The problem of inadequate facilities and infrastructure, together with poor incentives for teachers, are problems to be solved by government. Government has already accepted responsibility but if not for economic constraints

Statement of the problem

A school of thought has it that a teacher needs not be knowledgeable, he only need to know how to teach and he can learn to teach. No one disputes the fact that the professional teacher's knowledge of pedagogy or "methodology base" must be strong. He must be able to

- teach the concepts and skills (or all topics) in the mathematics curriculum, and
- facilitate the development of the principles and skills of numeracy, measurement and of the relationship involving space and shape.

The problem of how knowledgeable the teacher himself is as far as his subject is concerned is a pertinent issue and must be given due consideration. This problem can be traced to the little emphasis given to subject content knowledge in the curriculum designed for the teacher training institutions. About 75 per cent of the topics in the course outline in the first year is purely methodology oriented. There is nothing wrong with that. However, is it not logical to know what to teach before thinking of how to teach it?

As Educational Researchers Kanchak & Eggen (1989) point out

Education has always been one of the most rewarding professions but at the same time, it continues to be one of the most difficult in which to perform well. An effective teacher combines the best of human relations, intuition, sound judgement, knowledge of subject matter and knowledge of how people learn – all in one simultaneous act.

Perhaps you are familiar with the nineteenth-century playwright and satirist Shaw's (1903) comment about teachers: "He who can does. He who cannot teaches". This remark assumes that teachers cannot do what they teach. Also inherent in this assumption is that anyone can teach.

Teaching, as we know, is a profession and we may describe it as an art or a science. As a profession, one of its main characteristics is the possession of a body of knowledge and the ability to apply that knowledge in the classroom. Many critics of teacher education programs believe that teachers are ill prepared for the challenges of the contemporary classroom as far as knowledge of subject matter is concerned. Most people agree that teachers' knowledge of mathematics is essential to their ability to teach effectively.

Yet historically, researchers have had great difficulty elucidating the roles that mathematical knowledge plays in effective mathematical teaching. Grossman *et al* (1992) and Thompson (1992) have observed that 'how one teaches a subject is influenced greatly by the many ways one understands it'. A look of Teacher content knowledge assumes greater significance given the demands of recent reforms brought about by the government's Free and Compulsory Universal Basic Education (fCUBE) initiative.

An interesting parallel in Science was discussed by Carlsen (1990), who investigated the subject-matter knowledge of four teachers and concluded that when teachers were teaching unfamiliar topics, they tend to talk longer, rely on low-cognitive questions and use seatwork and non-laboratory projects.

Shulman (1986) claimed that thinking properly about content knowledge requires understanding the variety of ways in which the basic concepts and principles of the discipline are organised to incorporate its facts. This organization is important for as Broadly (1991) indicates

where (teachers) knowledge is more explicit, better connected and more integrated, they will tend to teach the subject more dynamically, represent it in more varied ways, encourage and respond fully to student comments and questions. Where their knowledge is limited, they will tend to depend on the text for content, de-emphasise interactive discourse in favor of seatwork assignments and in general portray the subject as a collection of static, factual knowledge.

And this is what is happening in our schools. The teacher uses mainly non thought provocative questions, and often selects only what he/she thinks can teach.

The logical conclusion that arises is lack of confidence on the part of the teachers. That is, a mathematics teacher whose content knowledge base is not solid has no confidence in himself. This may result in accepting wrong answers from his student after a slight argument or discussion in a mathematics lesson. With a strong content background, it is easier once creative to develop the appropriate methodology with a slight push.

The educational reform program was implemented in 1987 to address some of these problems and to make education more meaningful and relevant to national needs. However, the implementers of the program (The classroom Teacher), were not involved in the formulation of the program. The classroom teacher had little or no knowledge about the reform program for which he was to take a central role. Consequently, the performance of Pupils did not see any appreciable change in the positive direction.

The Case of UCEW

The policy document on the Free and Compulsory Universal Basic Education (fCUBE) spells out University College of Education, Winneba's (UCEW) role in the fCUBE program. It states that

UCEW has been set up as a teacher education institution to produce teachers required in basic schools by the Ghana Education Service.

This is the policy statement which has been *interpreted* in some educational circles to mean that the content knowledge of education students need not to be high since they will be teaching at the basic schools, where these content courses are not taught. This is evident by the removal of the so-called *abstract* and *difficult* courses, which was being offered in the Department of Mathematics Education of the former Advanced Teacher Training College, during the transition period. One wonders the rational behind the removal of these courses only to be replaced by low-level, no-demanding cognitive domain courses which only deceive students that they are reading serious mathematics in a University. This interpretation is wrong and if care is not taken, it will jeopardize our educational reform program, and the performance of our children will continue to be on the downward trend.

According to Arther et al (1995), effective teachers are knowledgeable, have a strong general background and understand the subject material at a high level. This assertion is confirmed by the Cockcroft Report (1982). It is emphasized in this report that the mathematical training provided at University for those who will become mathematics specialist in schools should aim among other things to:

- develop knowledge and mastery of mathematics substantially beyond the level at which they will be teaching and also where appropriate, provide opportunity to pursue some topics in depth;
- develop enjoyment of mathematics and confidence in its application;
- provide an appreciation of the relationship between mathematics and other fields of study and application
- Develop the ability to communicate mathematical ideas both orally and in writing.

Until recently, UCEW was running two diploma and bachelor of education programmes for its students:

- i) Track A-This program was meant for those students who would be posted to the Senior Secondary Schools to teach both Core and Elective mathematics. In this program, more emphasis was placed on content than methodology.
- ii) Track B-Students, who read courses in Track B, was to be posted to the junior secondary Schools to teach. In this program, more emphasis was placed on the methodology and little content courses were mounted for students to read.

A survey conducted by the writer on students in the Mathematics Department in 1998 revealed that about 82 per cent of the student population are in favour of the development of content knowledge beyond the level at which they will be teaching. One of the reasons they gave was that "our university should not be inferior to any University in Ghana and elsewhere in terms of competence of its products". The survey also indicated

that the students believe a graduate from UCEW should be able to teach mathematics as competently as products from university Cape Coast or Kwame Nkrumah University of Science and Technology.

But can we say graduates from UCEW can really teach mathematics as competently as products from university Cape Coast or Kwame Nkrumah University of Science and Technology? The 1997 External Examiner's Report for the Mathematics Department stated that

The mathematics content of the B.Ed Track B program should be the same as the mathematics content for the B.Ed Track A program. The emphasis on the Track B program should be how to teach the content of the primary and junior secondary curricula.

It will be wrong for the University College of Education of Winneba to produce graduates with B.Ed. Degree in Mathematics Education who do not have sufficient background in mathematics to be able to teach elective mathematics in senior secondary schools. There is an acute shortage of mathematics teachers in senior secondary schools. We have not yet reached the stage where mathematics students in a University College are awarded degrees which qualify them to teach mathematics only in primary schools and junior secondary schools."

Further Studies

General education has been defined as that portion of the educational programme, which deals mainly with preparation for life in the broad sense of completeness as a human being, rather than in the narrower sense of competence in a particular lot. It is logical to think that in every year-group of graduates from a university, at least one of the graduates will aspire to go on further studies. If students are denied adequate content background, how can they continue to do their Masters Degree and later the Ph.D.? If even only one person out of the lot has the ability to further his studies, he must be catered for in the under graduate program. All kinds of students should therefore be taken into consideration when drawing and designing academic programs and courses in any educational institution.

The acute shortage of young mathematics lecturers in our universities may be due to several factors. Definitely, one of such factors is the lack of confidence in the students. Since their knowledge in the subject matter may not be strong enough to enable them pursue postgraduate studies in Mathematics. This assertion is supported by the call of the Director of the National Center of Mathematical Sciences, Professor F.K.A. Allotey, to find solutions to the almost not existing mathematicians in the country. Professor Allotey alleged that there is only one pure mathematician in Ghana in his welcome address at the opening of the 6th Edwaed A Bouchet Regional College on Functional Analysis and its Applications to Differential Equations, from July 10 20, 2000. The fact is that a good teacher cannot teach effectively unless he is adequately equipped with the subject matter.

Any deviation from this may cause havoc to the training of the younger ones in our society to be responsible citizens in future. In some few years to come, these students are going to wear our coats and if care is not taken, they may go without shoes and ties. We have many potentials amongst our students and we need to find solutions to the factors that militate against their academic development.

Policy makers

The people in the helm of affairs of education in our country are those who have educational background in a specified area. These must be people who are knowledgeable in both methodology and content, since policies for mathematics education largely depend on mathematicians. I wonder how supervision can be effective if people who are in charge of mathematics education in this country have not got a good hold on subject content knowledge in mathematics. Consequently, lack of adequate content knowledge in mathematics will lead to bad and damaging policies being formulated, hence poor performance.

Suggestions and Conclusion

From the above discussion it is clear, that adequate knowledge of content is important and necessary for the classroom mathematics teacher. This will make him more efficient and effective in the classroom. The Government must continue to provide adequate facilities and infrastructure in the schools.

The part we as mathematics teachers, researchers, educators' and curriculum developers can play enhance the content level of the subject are stated next.

- i. First, our curriculum developers must accept that the knowledge of subject matter in the training of a mathematics teacher in particular and the classroom teacher in general is as important as the methodology aspect of it.
- ii. The course outline in our Teacher Training Institutions should be reviewed in a more pragmatic approach.
- iii. There should be a judicious balance between the topics in the methodology and the content. The number of topics in the content area must be increased to about 60 per cent.
- iv. The team of course outline writers for both the basic schools and the teacher training institutions should not only comprise of mathematics educators as is the practice over the years, but also personalities who are pure mathematicians. They will ensure that balance between the methods and the content. After all, we are all working towards a common goal.
- v. Students should be encouraged to appreciate the need for both methodology and content courses.
- vi. Negative remarks about content-based topics from people of high positions in education should not be encouraged.
- vii. Those who teach mathematics in the Teacher Training Colleges and the Tertiary Level must have a sound background in pure mathematics in their first degree as is done every where around the globe.
- viii. Periodic workshops should be organized for Circuit Supervisors not only on the methodology aspect but also the content area of mathematics. This will enable the supervisors to be more confident in their work.

- ix. Subject teaching should be encouraged at least in Mathematics and Science from Basic Four.
- x. The Universities must make sure that their products are competent and that their presence in the schools brings a lot of impact in the positive direction.
- xi. Our university professors in the Department of Mathematics should encourage young graduates to further their studies by way of making the subject friendlier and to see these post-graduate students as future colleagues.

This noble objective can be achieved if we instill confidence in our students by way of giving them adequate content-base courses.

References

- Arthea J.S.R and Verna E.B (1995) *In the Classroom: An introduction To Education*_USA: The Dushkin Publishing Group, Inc.
- Brophy, J. E (1991) *Teachers subject matter knowledge and classroom instruction*
Greenwich, CT: JAI Press.
- Carlsen, W (1990) *Teachers knowledge and the language of Science Teaching*: Atlanta, GA
- Charles H.B et al (1965) *The teaching of Secondary Mathematics*: USA: McGraw-Hill Inc.
- Clarke D.M (1997) *Journal for Research in Mathematics Education* (1997) Vol. 28
Number 3
- Cockcroft *et. al* (1982) *Mathematics Counts*: London:_HMSO.
- Griffiths A, H B. & Howson, A. G. (1974) *Mathematics Society of Curricula*
Cambridge University Press, London.
- Grossman, P. L et al (1992) *Teachers of substance: Subject matter knowledge*
New York Macmillan.
- Thompson A.G & Thompson P.W (1996) *Journal for Research in Mathematics*
-

Mathematics Teaching/Learning in Basic and Senior Secondary Schools

COFIE⁷ P.O.

Abstract

In spite of much improvement in the academic staff of training colleges in the area of Mathematics Education as well as yearly organisation of maths and science clinics, little evidence is found in the improvement of performance of pupils/students in our schools. Improvement is measured by the performance of students at the BECE, and SSCE the results, of which seem to be very low over the years. Studies done, however, suggest that the improvement in mathematical attainment of pupils/student does not only depend on good staffing in our schools. There is therefore the need to explore factors that will help to improve upon the performance of pupils/students.

Introduction

In recent times, mathematics achievement of Ghanaian children has been a subject of intense discussion among educators, policymakers and the public at large. Though we all agreed that ways and means should be found in raising the level of performance, it seems much of the workload is placed on the mathematics specialist in the field. We overlooked the efforts being made by these specialist teachers and how they could be encouraged for better performance in their teaching. No mentioning is made of what policymakers have put in place to motivate these teachers who are already over-burdened with heavy workload.

Cooney et al (1975), stressed that teachers should not always be held accountable when students are not successful in learning subject matter, and that a teacher's performance should be based not only on results gathered from test scores but also on the seeming appropriateness of classroom techniques.

Mathematics is not only restricted to the development of the child but also to that of the society. It is therefore not surprising that the subject has pervaded the entire organised activities of the Ghanaian Society. One of the national objectives of Basic Education is to prepare the child for life after school and it is only the teaching/learning of Mathematics that can prepare the child adequately to fit into the society. A good foundation in mathematics is very essential for the success of the child in life. It is for this reason that mathematics is made a core subject at the first and second cycle schools.

The teaching and learning of this subject, according to policymakers, has met with failures. The subject provokes the strongest emotions of distaste, anxiety and ill feelings among children. Only few, they say, are able to perform well in it.

A key strategy of the government development plan to become a middle-income country by the year 2020 is a nation-wide, sustained effort to expand, strengthen and make education more relevant, hence, the launching in 1987 of

⁷.Cofie, Primrose O. is a lecturer in the Department of Mathematics Education, UCEW.

the Educational Reform programme. Though the reform programme has succeeded in increasing the intake of pupils in basic and senior secondary schools, it is claimed that little success has been made in delivering quality teaching and outcomes in mathematics as indicated in Table 1.

Table 1 National CRT Result by % Mean Scores (Public Schools)

	1992	1993	1994	1995	1996	1997
Mathematics	27.3	27.4	27.7	28.1	28.8	29.9
English	29.9	30.9	31.0	31.6	33.3	33.9

From the Table, the mean score in Mathematics increased from 27.3% in 1992 to 29.9% in 1997. Within that same period in the BECE and SSCE there was a steady increase in the performance of students at both exams. (BECE, SSCE Results 1992 - 1998).

On the other hand policymakers took this increase in performance as below average and in one instance a whole teaching staff was transferred from a school.

Much as we should, as mathematics specialists, accept some of the blame for the slow pace in which we are making progress, policymakers should not forget the numerous obstacles exerting influences on the whole school system in the quest for more quality teaching.

These are obstacles attributable to:

- parents
- pupils / students difficulties in learning
- policymakers
- pre-school mathematics experiences
- problem of school mathematics.

Let us critically examine obstacles related to teachers.

Parents

Parents can exercise a considerable influence on their children's attitude to mathematics. Their own schooling has much to do with how they view mathematics. A parent who expresses the value of education and offers assistance to the child is likely to encourage the child to learn and do well in school. Cooney, et al (1975), pointed out that sometimes parents provide a rationalisation for their child to excuse poor performance in mathematics. Some parents even sympathise with their children for poor performance. This may lead to failure to work by a child on the assumption of a hereditary shortcoming in the subject.

Parent's Experiences as Teachers

We can look at teaching as a profession with a gender and familial nature. Women play the role as mothers nurturing and caring and men as fathers, disciplining and wielding power. Most of the teachers we have in the field are parents and being a parent can involve a significant change to one's priorities and values and to personal identity and sense of self. It can also make a difference as how other people see us, and consequently to the expectations they have for us. In a professional sense this can have both positive and negative implications. Positive because it can make it easier for us to relate to and

understand the children we teach, and equally significantly, their parents. Negative, in that it can cause others to question our commitment to work. As parents, teachers bring their experiences at home to bear on their professional, and theoretical knowledge. These are then reflected back on children in the classroom.

Teachers

Obviously, pedagogical factors have a lot to do with how readily we teach children in class. The student of a mathematics teacher who is inept in the application of mathematics principles will definitely experience a lot of difficulties, anyway. A good teacher needs not only do the right things but to do them for the right reasons and to be aware of what he/she is doing. Only then can the teacher counter criticism of his practice. If we do not allow a child to explore and find out how a rule came into being for solving problems, such a child will find it difficult understanding the underlying principle and process.

Positive Feelings

The new educational policy seems to have given mathematics teachers some control of what to do in their teaching. We are now given the chance to work on our own thought. But this means a collaborative rather than individual work. However, time is not on our side for such a collaborative work. Teaching and learning of mathematics is now much more competitive than making sure children acquire mathematical knowledge. We are therefore forced to aim at the brighter pupils in our delivering rather than helping to bring the average ones up. That is why we are these days, held accountable by the policy makers. This accountability pressure has often equated education with achievement test scores.

Negative Feelings

Despite the fact that the reform has given us some control, it has also brought about intensification of work and this has given many indications of pressure, tension and stress. This could be seen in phrases used by teachers of late such as “heavy workload”, “being asked to do too much”, and “extra jobs”. Despite all these phrases teachers still consider the child as the first and foremost in their profession.

Oversize Shoe

Majority of teachers teaching mathematics at the Basic level are over 35 years and most of them hold Teacher’s Certificate A (obtained in a 4-year post-elementary or 2-year post secondary Teacher Training Colleges). They find it difficult incorporating their own child-centred approach into the new technical framework of mathematics teaching and learning. They cannot therefore follow what the mathematics syllabus require of them. What they do is to fall on their own rich experience in the planning and development of their teaching strategies. To them, the new shoe (mathematics curriculum) cannot fit every child hence there is the need for differentiation of the mathematics curriculum. The present shoe is meant for those who will end up at the higher level of the educational ladder. The less capable and those without a large vocabulary take a long time to fall into what goes on in the mathematics classroom with the present curriculum.

Conclusion and Suggestions

- We have in our education policy, for far too long not looked at empirical reality of policy implementation in our Basic Schools.
- Much of what has become acceptable way of teaching mathematics and the common practice in the presentation of mathematics lessons do not help children to understand the subject. This needs to be examined.
- Differentiation of the mathematics curriculum having in mind the specific needs of existing groups and potential learners should be considered.
- Bottom up method is what is needed to address this neglect.
- Policymakers need to chart the effects of policy in the school from the teacher and also to understand what takes place from the inside.
- Policymakers should find out how official policy is interpreted by a teacher at school level. There and then they will realise that the responses of these teachers in the implementation of any policy should be based on their creative social actions and not on robotic reactivity.
- The Government as a matter of urgency should look into the possibility of establishing an Academy of Pedagogical Science, Art and Technology. The main function of such an Institution should be to research, implement and monitor educational policies.

If policy makers really care about quality, they would do well to turn their attention away from Curriculum Review and Development in Mathematics Education, monitoring, evaluation and accountability measures towards developing structures, purposes and programmes of Basic Education that will help teachers and pupils build a more solid emotional understanding with each other on which successful teaching of mathematics can truly be based.

References

- Ball, S.J. (1994) *Education Reform: A Critical and Post - Structural Approach* Buckingham: Open University Press.
- Camplell, R.J. and St. J. B. Neil, S.R. (1994) *Reform at Key Stage: Teachers Commitment and Policy failure*, Harlow: Longman.
- Cockroft, W.H. (1982) *Mathematics Counts. Reports of the Committee of Inquiry into the Teaching of Mathematics in Schools*, London: HMSO.
- Hargreaves, A. (1994) *Changing Teachers, Changing Times: Teachers' Work and Culture in the Post-modern World*, London: Cassell.
- Cooney et al (1975) *Dynamics of Teaching Secondary School Maths*, Boston; Houghton.